POWER PLANT ENGINEERING

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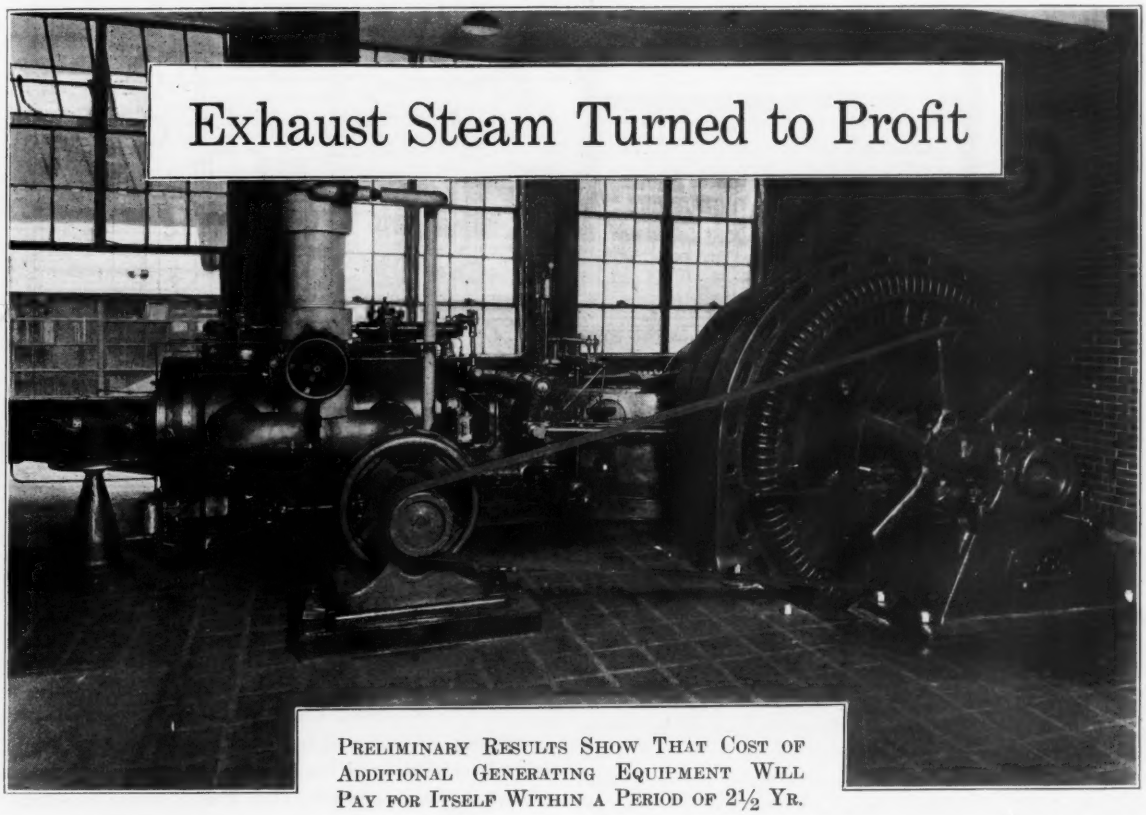


Exhaust Steam Turned to Profit

PRELIMINARY RESULTS SHOW THAT COST OF ADDITIONAL GENERATING EQUIPMENT WILL PAY FOR ITSELF WITHIN A PERIOD OF 2½ YR.

ECONOMIES which may be expected from the isolated power plant where there is a demand for exhaust steam have been fully realized in a newly constructed plant for The H. C. Godman Co., shoe manufacturers of Columbus, Ohio. All electric current required for the manufacture of 1500 dozen pairs of shoes per 9-hr. day was formerly purchased from the municipal power plant. Completion of the company's new power plant and two units of the new factory group have shown it advisable to operate one generating unit for the day shift of 9 hr. and purchase current for night lights from the municipal plant. When the leatherboard mill factory unit is completed, the night load will be such that the new plant will operate 24 hr. per day and current from the municipal plant will be used for night lights only, when that mill unit is not running.

Anticipated savings due to the new plant were based on a flat rate of 1.6 cents per kw.-hr. for purchased current. The power requirements were stated as 100,000 kw.-hr. per month. Present performance indicates that with the completion of all factory units and 24 hr. per day operation of the plant, the entire cost of the installation of additional equipment for generating power will be paid out in about 2½ yr. From this it is evident that the investment will prove an unusually profitable one; and that the application is one of good engineering practice and sound business management.

When completed, the entire factory group will contain 8,000,000 cu. ft. of space in which will be installed the equivalent of 84,000 sq. ft. of direct cast iron radiation. In addition to the steam required for heating is that low pressure steam which is used for drying and manufacturing purposes. The proportionate requirements are as given in Table I. The motor load consists of approximately 140 motors ranging in capacity from ¾ hp. to 100 hp., the average rating per motor is about 5 hp.

Until such time as the factory group is completed no more than the two present generating units will be installed. The generators, built by the General Electric Co., are wound for 3-phase, 60-cycle current and gen-

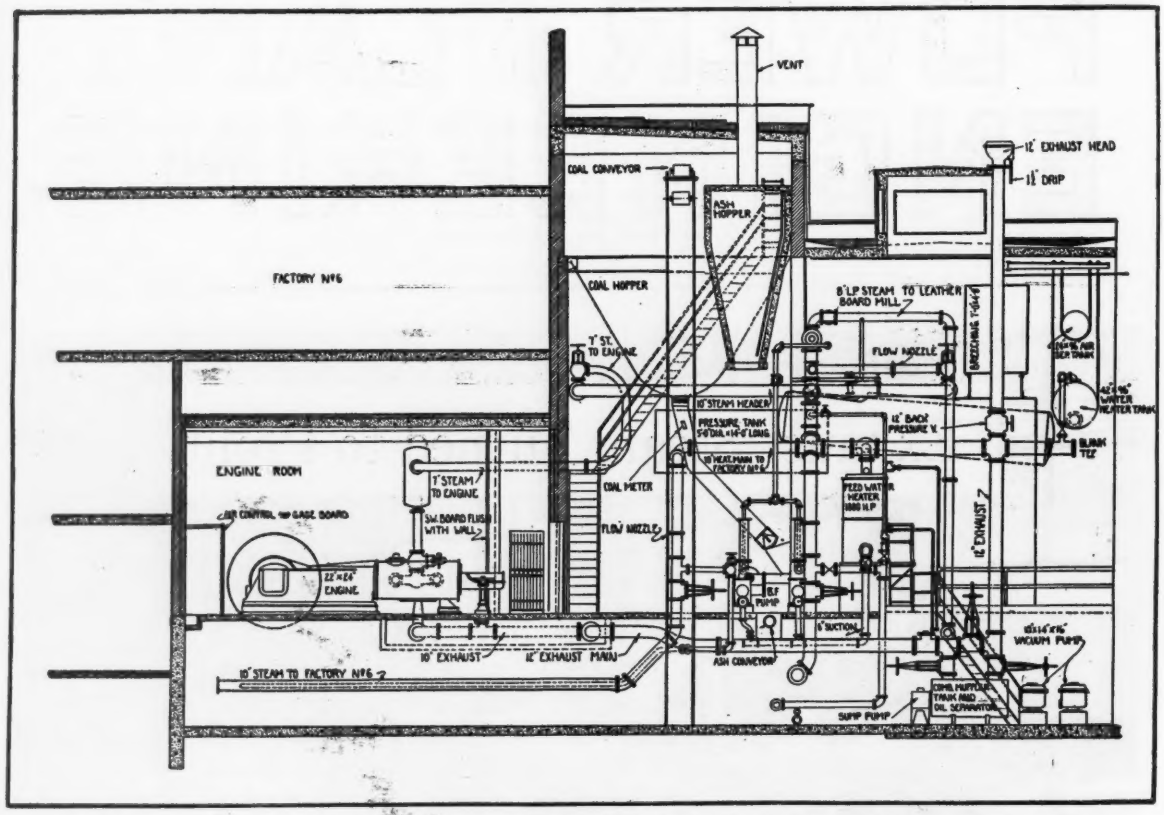


FIG. 1. SECTIONAL ELEVATION OF ENGINE AND BOILER ROOMS SHOWING SCHEME OF EXHAUST STEAM PIPING

erate at 450 v. They are rated at 416 kv.a. each, with a stated power factor of 80 per cent. The power factor as indicated at present at the switchboard is 75 per cent. Current is used at the generated voltage for all motors, and transformed to 115 v. for the lighting circuits. All purchased current is transformed from 2300 v. to 115 v.

Each generator is direct connected to a 22 by 24-in., 200-r.p.m. Universal Unaflow engine built by the Skinner Engine Co. These engines are right and left-hand and so set that the space between cylinders allows ample space for the chief engineer's desk. The main switchboard is located along the east wall between the two cylinders and the gage board is against the opposite wall between the two generators. The advantage of this arrangement is that the engineer occupies a central position. Practically everything that goes on within the engine room is within direct sight of his desk and he can reach either the switchboard or the stop valve with a minimum number of steps.

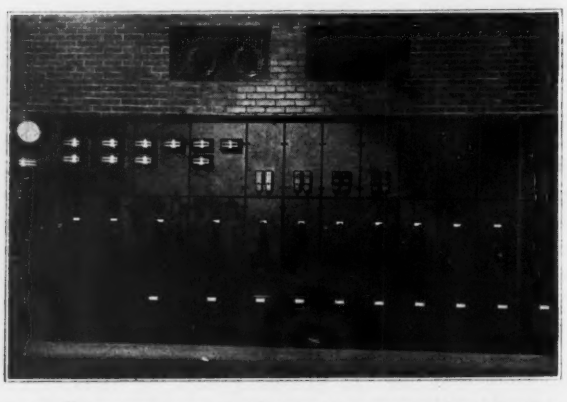


FIG. 2. BRICK WALL COMPLETELY ENCLOSES THE MAIN SWITCHBOARD

Factory Uses Exhaust Steam

Steam pressure carried at the throttle is approximately 150 lb. and the engines operate against a back pressure of about 1½ lb. The exhaust steam, as explained in detail later, is taken through a combination muffler and oil separator before distribution to the feed water heater and the factory units. Each engine is protected by a separator placed in the engine lead, these separators were made by The Direct Separator Co.

TABLE I. RADIATION AND STEAM CONSUMPTION IN FACTORIES

	Heating and Vent. based on direct C. I. Rad. sq. ft.	Drying pounds of steam per hr. average	Manufacturing pounds of steam per hr.
Factory No. 1	35,000	400	800
Factory No. 6	22,000	200	400
Leatherboard Mill	7,000	1000	100
Administration Bldg	20,000	....	...
Total	84,000	1600	1300

Engine cylinder lubrication is provided for by two Madison-Kipp Corp. sight feed lubricators which distribute oil to eight points in each cylinder. The bearing oil is circulated through coolers before being taken up by the pumps for redistribution. Oil storage is pro-

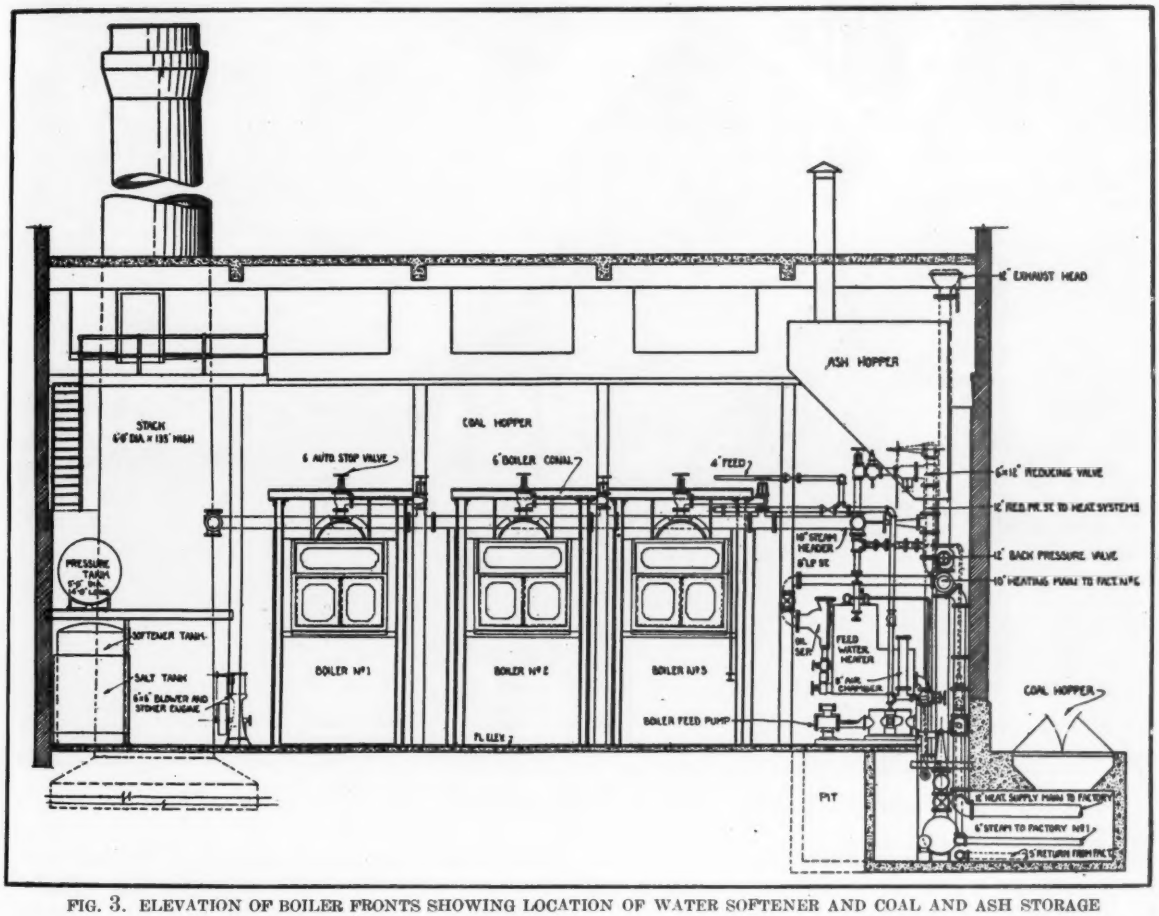


FIG. 3. ELEVATION OF BOILER FRONTS SHOWING LOCATION OF WATER SOFTENER AND COAL AND ASH STORAGE

vided for by a two compartment tank furnished by The American Oil Pump and Tank Co. The compartments, each holding 140 gal., are used for the storage of cylinder and bearing oil.

Each engine is equipped with a Golden-Anderson stop valve which closes at an engine speed increase of 10 r.p.m. The overspeed tripping devices are mounted at the main engine shafts. A manually operated trip is located at each engine valve and stop push buttons are mounted on the switchboard.

Excitation is provided by two General Electric Co.'s 125-v., 14-kw. machines, belt driven from pulleys on the generator shafts. The switchboard, also made by the General Electric Co., is of black oiled slate and is equipped with a voltage regulator, synchronizer, frequency meters and kw.-hr. meters in addition to the standard instruments. This board is completely inclosed up to the ceiling both in front and on the ends. The instrument board, manufactured by Colby-Merrill Co., is equipped with: one American Steam Gauge and Valve Co.'s steam pressure recorder, one Brown Instrument Co.'s steam pressure recorder, and two Bailey flow meters, which record the low pressure steam flow to the present factory units. There are also the necessary pressure indicating gages.

One extra panel has been provided on this board for a third flow meter to be installed when the third factory unit is completed. Pneumatic radiation control switches are also mounted on this board. A telephone communication system ties in the power plant with all manufacturing departments.

Red tile floor covering material makes an effective contrast with the glazed brick which surfaces the side

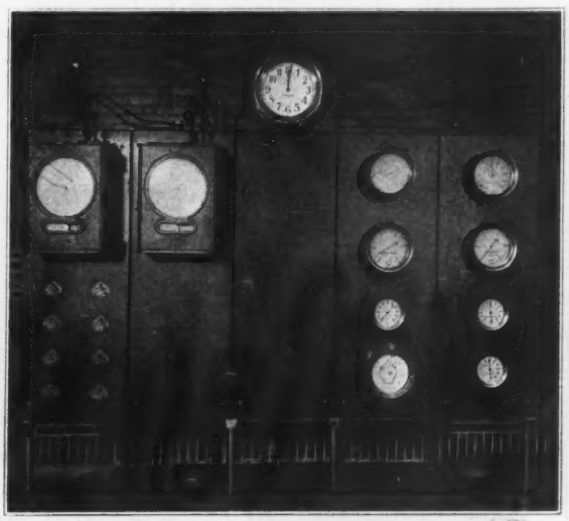


FIG. 4. INSTRUMENT BOARD ON WHICH ARE MOUNTED FACTORY STEAM DISTRIBUTION METERS AND RADIATION CONTROL VALVES

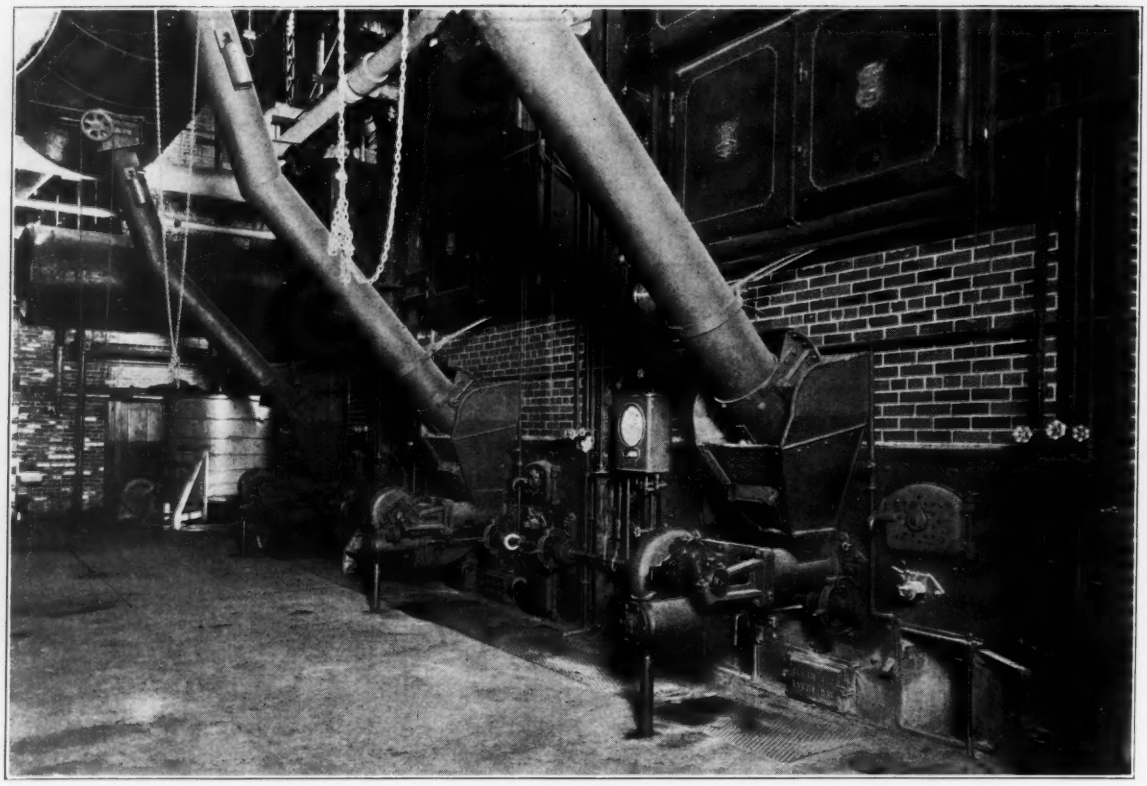


FIG. 5. COAL IS METERED AND SPOUTED DIRECTLY TO THE HOPPERS. ASH IS HANDLED BY A STEAM JET CONVEYOR

walls up to the ceiling. Ventilation has been provided in the engine room by means of two roof ventilators and one supply and one exhaust fan. The engine room is at present divided by a temporary partition, the removal of which will provide sufficient floor space for the third engine driven unit which will be installed with the completion of the third factory unit.

Coal Delivered by Trucks

Just outside of the south boiler wall is located a coal pit covered over with steel grating. Coal trucks dump directly into the pit from which the coal is taken by means of a Jeffrey bucket conveyor and delivered to the overhead steel bunker which is of 150 T. capacity. One down spout, of circular section, is provided for each stoker hopper. Each spout is provided with a Bailey coal meter and two gates, one at the bunker and one at the lower end of the spout. In this way coal may be cut off at the bunker for repairs to or removal of the spout, or the coal may be cut off at the stoker which eliminates dumping and rehandling that coal contained in the spout should stoker repairs become necessary.

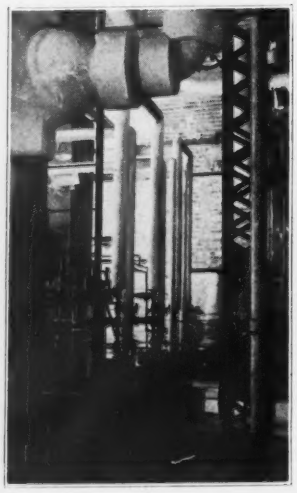
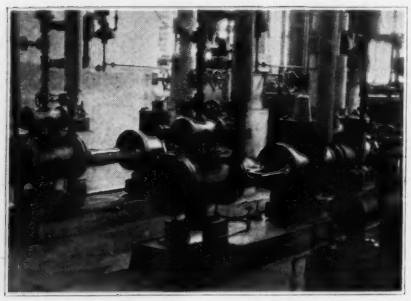
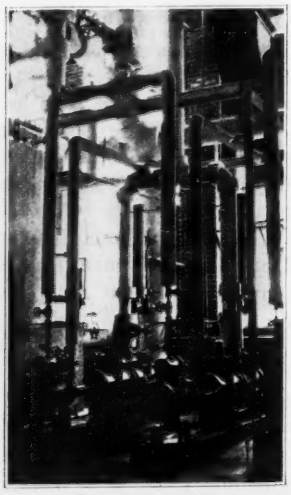


FIG. 6. TWO DIRECT ACTING FEED PUMPS ARE INSTALLED WHICH HANDLE WATER AT 212 DEG. F.



All high and low pressure auxiliary steam pipes and hot water pipes are insulated as shown in the picture to the right and to the left. Above are shown the two outside packed plunger feed pumps.



The coal used is all bought to size. This simplifies the coal problem by the elimination of a crusher plant.

Three 225-hp. Heine longitudinal drum boilers are in operation, the pressure carried is about 160 lb. ga., although the boilers were designed for 200 lb. pressure. Each boiler is equipped with a Golden-Anderson auto double cushioned triple acting valve, and Bayer soot blowers. The tubes are blown after taking on the load in the morning and again during the half hour shut down at noon.

Stoker equipment consists of three single retort Detroit underfeeds which are driven by means of a chain from an American Blower Co.'s 6 by 6-in. type A engine. This engine also drives, by means of a belt, the 60-in. steel plate American Blower Co.'s forced blast fan. When operating at 125 per cent of boiler rating the draft over the fire is maintained at 0.10 in. of water and the temperature of the waste gases averages about 500 deg. F. A Ruggles-Klingemann regulator is provided to change the stoker and fan engine speed and regulate the main damper to meet changes of load conditions. In this regulator steam pressure acts on a diaphragm which in turn actuates a pilot valve. Water under moderate pressure is used as the power medium.

Three Bailey flow meters have been provided, one of which is mounted at each boiler. Each meter is equipped with three curve drawing pens, one for steam flow, one for air flow and one for flue gas temperature. These meters are also provided with integrating devices which show the total steam flow.

Washout water is piped to several convenient points on each setting so that when washing out the boilers the workmen will be required to handle but a short length of hose.

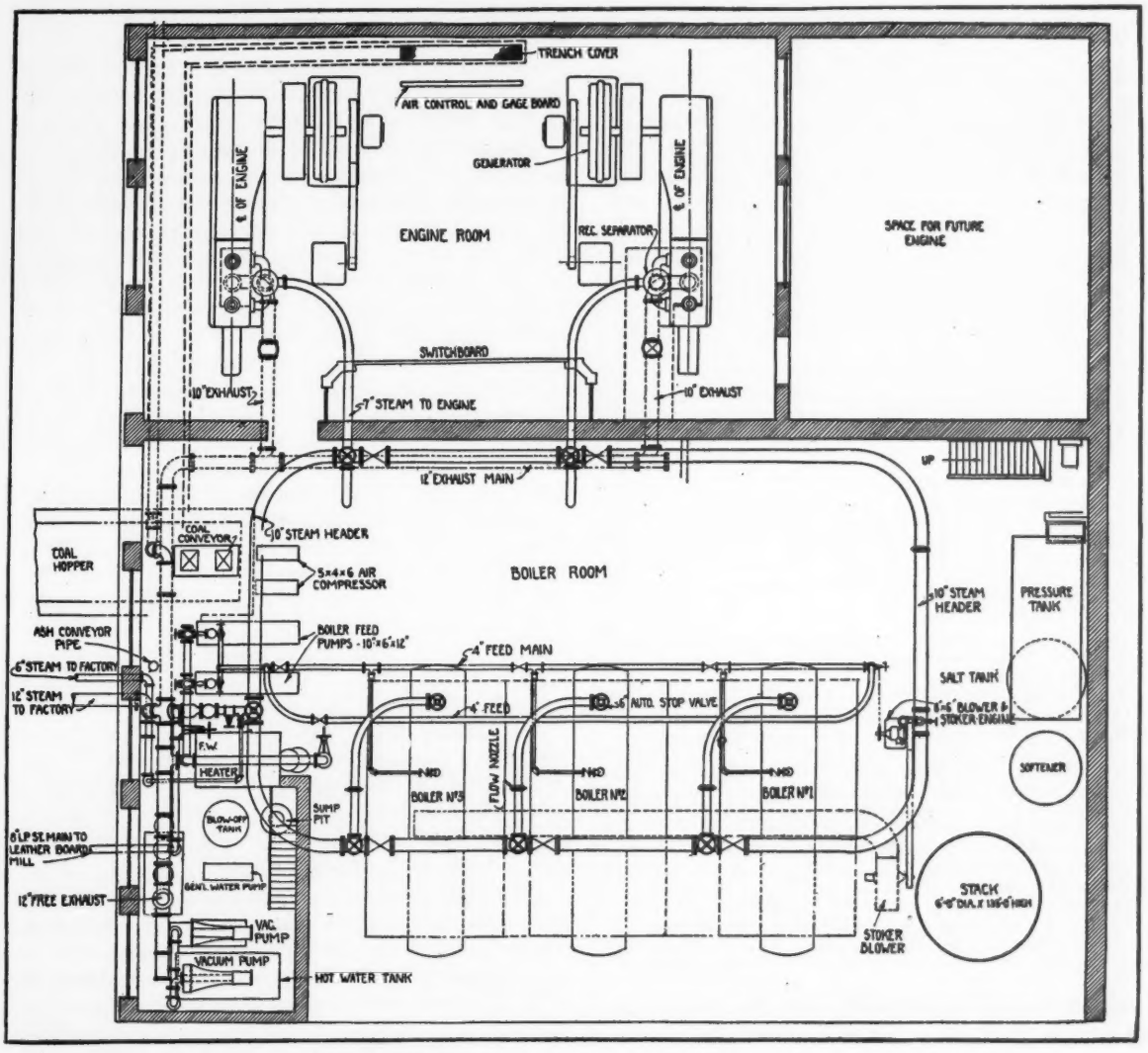


FIG. 7. HIGH PRESSURE STEAM AND FEED WATER PIPING ARE INSTALLED AS LOOP SYSTEMS

Ash is disposed of by means of a Detrick-Hagan steam jet ash conveyor which discharges into an overhead reinforced concrete ash hopper. This hopper is located in the south end of the boiler room and arranged so that the ash may be spouted directly to motor trucks near the point of coal unloading. This hopper is vented through the roof as a precaution against the accumulation of dust, and fire and explosion hazard.

One reinforced concrete chimney, constructed by the Heine Chimney Co., serves the three boilers. It is 6 ft. inside diameter by 135 ft. high and is lined with a second grade of fire brick for a distance of 30 ft. above the boiler room floor. The breeching is made of steel plate and is lined on the inside with Sil-o-cel insulating brick.

General construction materials used in the boiler room are concrete for the floor, brick walls and a reinforced concrete slab roof. Ventilation is provided for by means of a monitor section in the roof. The coal bin and conveyor are sealed off up to the ceiling so that dust encountered when loading coal into the overhead bunker will not settle in the boiler room.

TABLE II. TEST AT PLANT OF THE H. C. GODMAN COMPANY

1	Duration of test	8 hr.
2	Date of test	May 23, 1923
3	Kw. load by amp. and volts	249.7
4	Kw. load by wattmeter	244.3
5	Kw. load, avg. items 3 and 4	247.4
6	R.p.m.	200
7	M.e.p.	43.5
8	I.hp.	387.4
9	Ratio i.hp. to kw	1.565
10	Exciter kw.	6.43
11	Power Factor by meter	98.7
12	Power Factor by wattmeters	98.4
13	Boiler press, lb. ga	161.6
14	Engine header press, lb. ga	158.5
15	Engine throttle pressure at cutoff, lb. ga	148.3
16	Back press, lb. ga	1.6
17	Gross feed water total weighed, lb	73,844
18	Feed temp., deg. F	62.1
19	Total coal as fired, lb	10,821
20	Total ash as fired, lb	1,962
21	Per cent ash as fired	18.1
22	Per cent ash—by analysis	14.28
23	Per cent moisture—by analysis (as fired)	7.11
24	B.t.u. per lb.—by analysis (as fired)	10,871
25	Cost per ton delivered (coal)	$3.66
26	Coal by meter chute No. 2, lb	13,200
27	Press in air box, in. water	2.31
28	Draft in fire box, in. water	.067
29	Draft in uptake, in. water	.344
30	Flue temp., deg. F	532.8
31	Per cent CO_2	12.37
32	Boiler rating, actual, per cent	143.2
33	Factor evap. from and at 212 deg. F. (actual conditions)	1.203
34	Factor evap. from and at 212 deg. F. (guaranteed conditions)	1.046
35	Correction for feed at 212 deg. F	1.154
36	Steam per kw.-hr., inc. and aux. losses	37.3
37	Evaporation steam to coal as fired	6.82
38	Evaporation corrected for 212 deg. F. feed	7.87
39	Evaporation corrected for 212 deg. F. and dry coal	8.46
40	Boiler and stoker overall eff. (per cent)	73.10
41	Coal per kw.-hr. as fired, lb	5.45
42	Cotl per kw.-hr. (corrected for 212 deg. F.) lb	4.72
43	Coal per kw.-hr. (corrected for 212 deg. F. and the contract evaporation 8 lb.) lb	4.65

STEAM PIPING FORMS LOOP

High pressure steam leaves the boilers through long radius 6-in. leads; these connect into the 10-in. main header, which forms a loop within the boiler room. In addition to the auto stop valve at each boiler nozzle, there is an angle valve on each lead where it connects into the main header. Five sectionalizing valves are so placed that the loop system of piping will be effective for continuous operation in the event of the failure of a section of the main header. Two auxiliary branches are taken off this header, one at the north end to furnish steam for the stoker engine and one at the south end which provides steam for the ash conveyor, the steam driven pumps and for the connection to the low pressure steam lines. This latter connection is made through two Foster Engineering Co.'s reducing valves placed in tandem. The engine leads are taken off the top of the header through gear operated 7-in. angle valves. The steam then passes through two long radius bends to receiver separators which are located directly above the engine stop valves.

High pressure drips from the two engine receiver separators are drained to the feed water heater by means of high pressure traps. All other high pressure drips are returned directly to the boilers by means of a No. 2½ Holly gravity return system, the discharge chamber of which is anchored to the chimney at a height of 35 ft. above the boiler water line.

As previously stated, the factory is heated and furnished with process steam by means of low pressure steam which is furnished during the operating period by the exhaust from the unaflow engines and such auxiliaries as may be in operation. When the engines are not in operation or at times when the demand for low pressure heating and process steam is excessively great, high pressure steam is reduced in pressure and cut automatically into the low pressure header.

Exhaust leads 10 in. in diameter take the steam from the two engines to a 12-in. main low pressure header beneath the floor in the boiler room. The exhaust steam from the stoker and blower engine connects into the north end of this header and the exhaust steam from the pumps and compressors is connected into the south end. This header is carried first to a combined muffler and oil separator as manufactured by the Standard Steam Specialty Co. Valves are provided so that this separator may be bypassed if required. A riser then carries the exhaust up to a tee fitting above which is located a Cochrane Multiport back pressure valve. This riser then extends on through the roof and is terminated by a 12-in. exhaust head. Two branches lead off from the tee, one furnishing steam to the domestic hot water heater, and the other serving the feed water heater and the factory requirements of low pressure steam. It is into this latter branch that the connection is made for the reduced high pressure steam.

All high pressure piping is covered with 3 in. of 85 per cent carbonate of magnesia by the broken joint method, and all low pressure steam and hot water lines are covered with 1 in. Asbesto-cel. All covering is jacketed with 8-oz. canvas, which is sewed in place.

SYSTEM OF RETURN AND FEED WATER

Although city water connection at 70 lb. pressure has been provided, the regular source of water is from two 40 ft. wells, each served by a Weinman pump. These pumps discharge to a pressure tank and operate automatically, cutting in at 40-lb. pressure and cutting out at 50 lb. Air pressure is maintained in the tank by the two 5 by 4 by 6-in. Burnham air compressors installed for the automatic temperature control and manufactured by the Union Steam Pump Co. The well pumps are piped up so that either pump may be made to serve either well.

Water for wash basins and flushing is taken directly

from the pressure tank. All returns from the factory are brought in through two 10 by 14 by 16-in. Columbus Steam Pump Co.'s vacuum pumps, the discharge from which is raised to an overhead air separating tank from which the water is returned by gravity to the feed water heater. The domestic hot water supply and boiler feed make up are taken from the City Service and then through a Permutit softening system of 5000 gal. per hr. capacity.

Domestic hot water is maintained at an average temperature of 170 deg. F. by means of a Sarco temperature regulator. The service of this water through the factory is effected by a loop piping system, the circulation in which is maintained by a 1¼-in. Weinman centrifugal pump.

Feed water is heated to 212 deg. F. in a Swartwout open type heater which is rated at 1000 hp. The two feed pumps take their suction directly from the heater and discharge into a sectionalized loop header. These feed pumps are 10 by 6 by 12-in., outside packed plunger type as manufactured by the Columbus Steam Pump Co. Feed water is regulated to the boilers by hand.

All radiators throughout the factory are provided with automatic heat control except every fourth radiator, which is manually controlled to prevent freezing up the plumbing and the sprinkler system. Four thermostats are located on each floor. The automatically controlled radiation is shut off in two sections to each floor by means of the pneumatic switches already referred to as being mounted on the engine room gage board. This necessitated installing reverse acting diaphragm valves on the automatically controlled radiation. In the event of air pressure failure, these valves will close. The third floor of factory No. 1 is ventilated by means of fans and an air washer; these are provided with automatic temperature and humidity control. The results obtained due to cooling effect during the hot season have been entirely satisfactory.

Richards, McCarty and Bulford, architects of Columbus, were engineers for this plant. The actual design was in charge of K. A. Nylen, chief of the mechanical engineering department for the above firm. The operating problems remain to be solved by Joseph McCue, engineer in charge.

Coal Conveyors for Modern Power Plants

COAL HANDLING EQUIPMENT FOR STORING, RECLAIMING AND DISTRIBUTION TO BOILERS HAS BECOME INCREASINGLY IMPORTANT WITH VARIABLE COAL SUPPLY. BY J. E. BORLAND

ONE OF THE biggest items of expense in the operation of power plant boiler room is the cost of delivering fuel to the boilers and removing ashes. The economy of generating power may be appreciably affected by the system adapted for handling these materials. Consequently, in deciding upon the method of coal handling to be used at a proposed power plant, very careful consideration must be given to all the factors involved in order to insure the adoption of the best all around system. This selection is influenced to such an extent by local conditions that no general rules can be laid down, practically every new plant presenting peculiar conditions which make it an individual problem.

In stations of comparatively small capacity, and in cases up to several thousand kilowatts, coal is delivered almost exclusively by hand passing and wheel barrow. This usually proves to be the most economical method where hand firing is practiced and where coal is received very close to the boiler room, or, as in many cases, directly in front of the boilers. When it is required to move more than about 40 T. of coal per hour, however, conditions usually favor some form of mechanical handling equipment. This is especially true where labor is scarce or unreliable, and the elimination of a troublesome labor element may in itself be sufficient to warrant the installation of such equipment. It is obvious that the reliability and satisfaction to be obtained from modern apparatus operated by a few trained men will greatly exceed that to be expected from a large crew of coal passers. Under existing conditions it has become imperative that a large stock of fuel be maintained at or convenient to the power plant as a reserve to tide over periods of irregular supply from such causes as strikes or transportation failure. This requires an adequate system for receiving, stocking and reclaiming the coal, which is usually combined with equipment for delivery to the boilers.

There is great variety in the type and layout of apparatus used in coal handling systems, and this must necessarily be the case in order to meet the various local conditions encountered. As, with other classes of equipment, the proper selection of this apparatus is based on consideration of such factors as the capital charges on the initial investment, the cost of maintenance and depreciation, the operating cost and efficiency, the reliability and speed with which repairs can be made, the space requirements and the adaptability to local conditions. Mechanical handling systems may include:

Car dumpers.
Unloaders or bridges equipped with grab bucket.
Hoisting towers equipped with grab bucket.
Cableways equipped with grab bucket.
Locomotive cranes equipped with grab bucket.
Monorail cranes equipped with grab bucket.
Cable roads.
Aerial tramways.
Larry cars.
Chain and bucket conveyors.
Belt conveyors.
Flight or scraper conveyors.
Screw conveyors.
Skip hoists.

Various combinations of these forms of apparatus are used in different systems, as determined by local requirements. The majority of plants, however, may be grouped in a few general classes, as follows:

Where coal is received by rail and delivered directly to the boiler room.

Where coal is received by rail and delivered either to a stock pile or to the boiler room.

Where coal is received by water and delivered directly to the boiler room.

Where coal is received by water and delivered to a stock pile or to the boiler room.

Where coal is received by either rail or water and delivered either to a stock pile or to the boiler room.

The first class includes mainly plants of medium capacity taking fuel from privately owned mines or operating under conditions that insure a continuous supply of fuel. In these cases coal is usually received in bottom dump cars discharging into track hoppers, from which it is fed to the crushers by gravity, apron or reciprocating feeders. After being crushed to the required size the coal is elevated and distributed to overhead bunkers in the boiler room.

For elevating to the bunkers the tendency is to use belt or continuous chain and bucket elevators, although a number of installations have been made using skip hoists. The control for skip hoists has been developed so that either semi-automatic or full automatic operation can be obtained. From a standpoint of reliability and maintenance the advantage is probably with the skip hoist. Scraper conveyors or belt conveyors may be used to elevate the coal in cases where the angle of slope is small. For distributing coal to the bunkers at the top of the boiler room, the belt conveyor has lately gained prominence, but flight conveyors, cable cars and tilting bucket conveyors are extensively used for this purpose. The advantages claimed for the belt conveyor are lower power consumption and greater reliability. As the belt shows signs of wear, delays due to breakages may be usually forestalled, since splices can be made in a comparatively short time when necessary. A monorail hoist equipped with a grab bucket may be used to take coal from track hoppers or from gondolas and convey it to crushers located above the coal bunkers.

Where the storage space is available for stocking coal in the vicinity of the plant the apparatus outlined above is combined with equipment for stocking and reclaiming the coal. Locomotive cranes are largely used for this purpose while traveling cranes or bridges, cableways and monorail cranes, also find extensive use.

In seaboard and river cities large power stations are generally located on the water front to insure an adequate supply of cooling water for the condensing system. Such conditions usually afford means of receiving coal by water and in some cases the entire supply is received in this manner. When the station is located in a congested part of the city no provision can be made for storage of coal at the plant except that in the bunkers, but a stock is usually maintained at some convenient outlying point. With such plants, receiving coal in barges, the ordinary method of handling is to elevate the coal to the height of the boiler room by high speed hoisting towers, pass it through the crushers, and carry it to the bunkers by cable conveyors or horizontal belt conveyors. The hoisting tower is a structure on the water's edge having a boom projecting over the water, with a grab bucket suspended from sheaves on a trolley carriage traveling on the boom. A machinery room at the top houses the drums, motors and controllers for operation of the bucket. The bucket dumps into a hop-

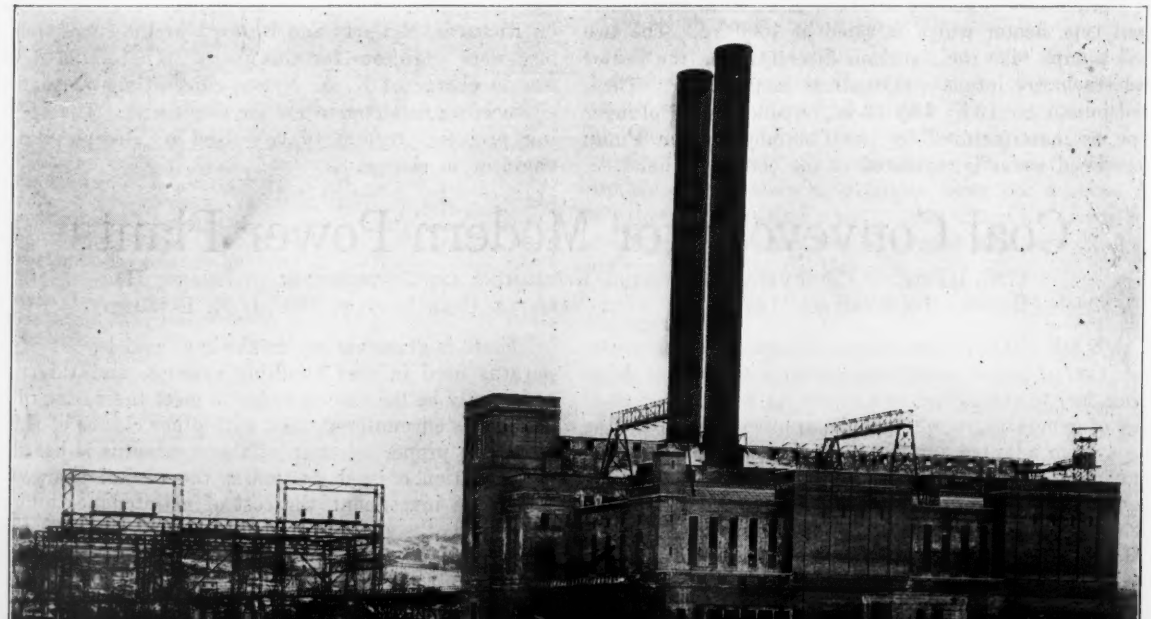


FIG. 1. COAL HANDLING EQUIPMENT AT THE COLFAX STATION IS RATED AT 400 T. PER HOUR

FIG. 2. THIS COAL RECLAIMING GANTRY CRANE HAS A SPAN OF 330 FT.

per near the top which feeds crushers located in the tower, and conveyors carry the crushed coal to the boiler room.

Where space is available for stocking coal at the plant, provision is made for delivery either to the boiler room or to the stock pile. This may be done by cable roads, conveyors or bridges while in addition reclaiming is often done by a cableway arranged with a fixed and a movable tower so that the entire storage yard may be covered by one cable, the plan of the stock pile being triangular in shape. In some cases belt conveyors are used to deliver to the boiler room from hoppers at the stock pile which are filled by cranes.

It will be seen from the foregoing that the equipment used for handling coal takes a great variety of form, and an attempt has been made to give a general idea of the principal classes found. A detailed description of the systems used at two modern power stations might serve to illustrate this more clearly.

Colfax station of the Duquesne Light Company, shown by Fig. 1, is located on the Allegheny River about 15 mi. above the center of Pittsburgh. It is designed for an ultimate capacity of 300,000 kw., two 60,000 kv.a. units in three elements each are now in operation. The

FIG. 3. BELT CONVEYORS DISTRIBUTE COAL TO OVERHEAD BUNKERS

location of this plant secures two important items in the economical generation of power, namely, an ample supply of condensing water and proximity to a coal mine. Coal is received from a privately owned mine and railroad having a cheap one mile haul to the plant, and space is provided along this railroad for a storage of 150,000 T. of coal (250,000 max.). This stock pile is covered by a 4-T. coal bridge of the rope-operated type having a span of 330 ft., traveling on rails parallel to the railroad track, as shown by Fig. 2. A section extending over the railroad track is provided with a hopper which can be filled by a 4-T. grab bucket. The hoisting speed is 200 ft. per min. and the trolley speed 1200 ft. per min., the capacity of the bridge being 267 T. per hr. when operating from the center of the stock pile.

Power is supplied to the bridge at 440 v., 3 phase, 60 cycles, the various motions being operated by wound rotor induction motors. The hoist and trolley motors are rated at 150 hp. and 100 hp. respectively. Four 20-hp. motors are used for propelling and two 5-hp. motors with

FIG. 4. TYPICAL ELECTRIC HOIST CONTROLLER PANEL

the rail clamps. Magnetic controllers are used on all operations of the bridge. The hoist controller is arranged to lower the bucket by dynamic braking, obtained by supplying direct current excitation to the primary winding of the hoist motor during lowering. Figure 4 shows the magnetic contactor panel controlling the operation of the hoist motor.

Coal handling equipment at this plant is in duplicate throughout, each half of the equipment having a capacity of 200 T. per hr. The railroad cars are dumped into two track hoppers having a capacity of 150 T. each, located at one end of the boiler room. Each track hopper discharges on an apron feeder to a double roll crusher, belt driven by a 50-hp., 580-r.p.m., 440-v., 3-phase, 60-cycle wound rotor induction motor. The apron feeder shown at the top is driven by a chain from one of the roll shafts. The advantage of belt drive for this class of service is that slipping of the belt will protect the rolls to some extent from possible damage by tramp iron in the coal. This apparatus is arranged so as to be as accessible as possible, and in addition the crusher is mounted on I-beams so that if necessary it may be shifted from the position shown to a point where there is ample room for repairs.

From each crusher the coal passes into a hopper feeding a carrier of the pivoted bucket type used to elevate the crushed coal to the top of the boiler room. This elevator travels at 60 ft. per min. in a rectangular loop, receiving coal from the crusher as it passes under the hopper spout, overlapping lips on the carrier providing clean delivery of coal.

All buckets are pivoted on the chain at the middle of each end, this construction allowing the bucket to retain a vertical position at all parts of its circuit except where

FIG. 5. ELECTRIC HOIST AND TROLLEY DRIVES FOR COAL BRIDGE

it is dumped at the top by means of a cam on the side meeting a curved rail placed in its path so as to cause the bucket to tilt forward and discharge its contents into the hopper. Each elevator is driven by a 50-hp., 870-r.p.m., 440-v., 3-phase, 60-cycle wound rotor induction motor connected through reduction spur gears to a sprocket wheel located at the top of the vertical loaded section.

Each elevator delivers to a belt conveyor, a continuous sample being removed at this point which is subdivided for analysis. The boilers are arranged in a double row facing a central firing aisle above which is a reinforced concrete bunker having a capacity of 10 T. per lineal foot, or 240 T. per boiler. This bunker is covered by two 36-in. belt conveyors, having a distance of 450 ft. between centers of end pulleys. Figure 6 shows the hopper receiving the discharge of the bucket elevator and feeding one of the belt conveyors. Each conveyor is equipped with a traveling tripper which is driven by the belt and may be started, stopped or reversed by an attendant, or will reverse automatically, at each end of the horizontal run. Each of the belt conveyors is driven by a 20-hp., 870-r.p.m., 440-v., 3-phase, 60-cycle, wound rotor motor, induction type, connected through double reduction gears to the upper pulley. The return belt is cleaned of fine coal dust by a rotating brush located under the pulley and driven by a small chain.

For the control of this conveying system an automatic starting panel is provided at each motor, the panel consisting of magnetic primary and accelerating contactors, together with the necessary control switches mounted on a slate base and enclosed in a dust-proof steel cabinet.

Each starter is provided with a double-pole double-throw selector switch which in the upper position provides for operation of the corresponding motor from a "start" and "stop" push button mounted on the panel. With the selector switches all in the lower position the system may be started or stopped by any one of the four push button stations distributed along the runway between the two belt conveyors. Pressing one of these start buttons energizes the closing coil of the primary contactor for the conveyor motor, which connects this motor to the line with the full amount of the external resistor in the rotor circuits. This motor is then automatically brought up to full speed by three secondary contactors which short-circuit the external resistor in three steps, the closing of these contactors being governed by series accelerating relays. Closing of the third secondary contactor short circuits the external resistor, and interlocks on this contactor disconnect the coils of

FIG. 6. COAL IS FED TO RECEIVING END OF BELT CONVEYOR FROM A HOPPER

the first and third secondary contactor and energize the primary contactor on the starter for the elevator motor. This operation is repeated automatically for the crusher motor and the system is then operating at full speed. Thus only the momentary pressing of a "start" push button is required to start the system, in the proper sequence to prevent piling up of coal at any point. All three motors may be stopped simultaneously by one of the "stop" buttons.

For delivering coal to the stoker hoppers, the boiler room is provided with two 20-T. weighing larries equipped with recording registers. These larries travel over the firing aisle, taking coal from the bunker overhead and filling the stoker on either side. An accurate record is kept of the amount of coal fed to each boiler.

Springdale station of the West Penn Power Co., also

located on the Allegheny River about 2 mi. above Colfax, has a present capacity of 50,000 kv.a. in two units, which is to be increased in the near future. Coal is obtained from a private mine located on the opposite side of the river, the mine cars being hauled through a tunnel beneath the river to the bottom of a double compartment shaft adjacent to the power plant. The coal is hoisted in 7-T. bottom discharge skips operating in balance with two skips suspended in tandem in each compartment, only the bottom one being used at present. A completely equipped tipple is used for loading cars for shipment, if desired. Duplicate triple roll crushers receive coal from reciprocating feeders and deliver to a 42-in. belt conveyor up a 20-deg. slope, 316 ft. long to the top of the boiler room, the belt traveling at 400 ft. per min. A 75-hp. motor drives the belt.

Boilers are arranged for operation from three firing aisles each of which is covered by a steel and concrete bunker. Coal is supplied to the bunkers by three 30-in. belt conveyors equipped with traveling belt trippers. The conveyor from the coal tipple enters the power house at one end of the middle bunker and two short inclined 30-in. belt conveyors at right angles are provided so that coal may be delivered from the main conveyor to any or all of the three distributing conveyors. A continuous sample is taken as the coal leaves the main belt. From the bunkers coal is fed directly to the stoker hoppers.

Track hoppers near the tipple are provided for the receipt of coal by rail, if necessary. An inclined apron conveyor from his hopper delivers to a third triple roll crusher in the tipple, the crusher discharging to the main 42-in. belt. The crushing and conveying equipment at this plant is operated by 440-v., 3-phase, 60-cycle wound rotor induction motors, using chain drive. Drum controllers are used with all motors.

These two modern installations give a good indication of the variety of conditions encountered in the handling of coal at power plants.

Notes Regarding the Use of Grease*

THE USE OF GREASE PRESENTS MANY ADVANTAGES, BUT IT MUST NOT BE CONSIDERED AS A "CURE ALL" FOR LUBRICATION TROUBLES

GREASES, OR, as they are sometimes termed, semi-solid lubricants, are essentially intimate emulsions of mineral lubricating oils and soaps from animal or vegetable fats, the emulsifier being water or some other agent. The mineral oil is entrained in the soap, which serves as a thickener, much in the same way that water is held by a sponge. The resultant mass is homogeneous in appearance and action if the mixing has been properly carried out. As understood today semi-solid lubricants are of such density that they will not flow readily at ordinary temperatures. While most semi-solid lubricants are mixtures of mineral oils and saponified animal or vegetable fats, these latter, such as tallow, lard and palm oil, as well as certain pure mineral products of the nature of petrolatum, are also classed in this category. Essentially the generally accepted classification is as follows:

1. Pure mineral grease such as petrolatum, gear lubricants, and other highly viscous products.

2. Pure animal and vegetable fats such as tallow, lard, and other non-fluid products.

3. Mixtures of pure fixed oil fats and pure mineral greases.

4. Mixtures of soaps and mineral oils, such as cup, sponge and railroad greases.

Products included under Nos. 1 and 4 are most commonly used as lubricants where grease lubrication is desirable. Under classification No. 4, we have what are known to the grease maker as hot and cold set greases, i. e., greases that are mixed while hot and those that are cold mixed. Cold mixed products include axle and railroad greases, while the various grades of cup and sponge greases are hot mixed. By varying the constituents such greases may be produced in many grades, each having characteristics intended to fit it for a particular type of service.

In the cold mixed greases, the chemical action takes place in the shipping container immediately after mixing and the grease has been poured. In the hot mixed greases, chemical action occurs in the mixing kettles. In both cases the result of such reactions is the formation of the soap body of the grease. While the lubricating value of grease depends to a large extent upon the lubricating value of the oil used, on the other hand the grade and amount of soap used will naturally have a certain effect upon the general appearance, body and other physical characteristics of the resultant product.

PROPERTIES GREASE SHOULD POSSESS

Whatever the type of service it is designed for, lubricating grease should possess certain very definite properties if it is to give successful and satisfactory results, viz:

1. Its melting point and hardness should be definitely adapted to the operating temperature and pressure where it is to be used.

2. It should have sufficient body to insure a film of lubricant between the bearing surfaces under the maximum possible pressure that might occur.

3. It should contain no so-called non-lubricating fillers such as asbestos, talc, soapstone or chalk, which are used mainly as cheap mediums to give greater viscosity or body. Such substances will contain a certain amount of grit and will cause scoring of the bearings.

4. It should not have a rubbery appearance, inasmuch as this is an indication of too little water used in mixing, and such a grease will almost always separate later on.

5. It should be as free as possible from the tendency to decompose, oxidize or turn rancid on exposure to the air.

6. It should not be liable to gum or clog the oil ducts, however adverse the operating conditions.

7. It should be absolutely homogeneous and of uniform consistency throughout, and there should be no impurities or lumpy matter present to cause clogging of the lubricator, grease cup or oil ducts.

ADVANTAGES OF GREASE AS A LUBRICANT

In the matter of comparing grease with oil for lubrication purposes there is involved essentially a prior con-

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sideration of machinery details and the relative adaptability of each lubricant for the service intended. The question of where and when to use grease lubrication therefore requires an intimate knowledge of machinery operation and the science of lubrication. This will be taken up later on.

There are, however, certain well defined characteristics possessed by greases which tend to give them decided advantages in many cases. Theoretically grease lubrication is best suited to low speed service. By virtue of the fact that a grease film is normally thicker than an oil film (at low operating speeds) due to its generally greater body, the rate of distortion in the film will be less. It is uncertain whether this condition would hold under higher shaft speeds, since the questions of pressure, bearing area and means of applying the lubricant would, by their effects, render each case individual in its operation.

Another advantage grease lubrication presents is the usual total freedom from splashed or dripped lubricants. In certain types of machinery leakage of the lubricant to the product being handled will practically ruin the latter. Means of lubrication on much of the equipment used therein renders cleanliness of the bearings and other wearing parts practically impossible were oil to be used. Hence, it is necessary to resort to grease which is applied by compression grease cups, gravity or pressure lubricators.

Disadvantages

It can readily be inferred from the above that inasmuch as greases are chiefly of advantage in lubricating slower speed high-pressure units wherein a relatively thick film of lubricant is desirable, they will be disadvantageous under high speed conditions. There has been extensive effort in certain technical articles and advertising bulletins to promote the use of grease by decidedly ambitious statements as to its qualifications. In fact, such propaganda would very frequently lead the layman to believe that a grease is a "cure-all" wherever a lubricant is required. The use of grease, however, is clearly limited to the lubrication only of such points as are favorable to its application.

One of the most decided disadvantages pertinent to the use of grease is the possibility of lack of stability. Unless grease is skillfully and scientifically mixed, and the highest grade of ingredients used there will be a marked tendency towards lumpy separation of the oil and soap constituents. This occurrence wll be especially likely if the grease is stored over any length of time. Separation is usually a result of using excess heat in mixing such products as cup and sponge greases. If the grease maker is not an adept at his art, frequently he will overheat the batch in an endeavor to brighten it. This is fatal and such a grease will nearly always separate sooner or later.

Another disadvantage that is frequently claimed is that greases today are relatively non-uniform in character. That is, the grades of various manufacturers will differ markedly in regard to consistency and melting point, etc. This is due to the fact that there is little or no conformity among grease makers as to specifications, especially regarding consistency, tests for which are crude and undependable. Many such products are marketed today simply under a numerical designation, and a No. 3 Cup Grease made in St. Louis may be so different from a similarly designated grease made in New York that for service adaptable to one, the other might often give rise to serious lubricating difficulties.

Where and When to Use Grease

In general engineering practice certain manufacturing and operating conditions will be frequently encountered which cannot be handled effectively by lubricating oils, and it may be desirable or even necessary to resort to grease. Essentially these conditions would be:

1. When the oil cannot be retained in and around the bearing, due to "squeezing out" caused by high pressure, slow rubbing speed or high operating temperature.

2. In cases where any liability of oil splash or drips would involve damage to belting or the materials being handled by the machine, as for example in the textile mill.

3. Where the bearing may be subject to repeated shocks as on the motor car chassis, which would tend to break the lubricating film.

4. Where it is desirable to insure positive lubrication using a comparatively small amount of lubricant, and yet have a sufficient reserve to enable the part to operate with relatively little attention for a considerable length of time. This particularly applies to inaccessible bearings where gravity feed grease cups are used, and where the use of oil would entail shutting down of the machinery for attention.

5. Where relatively high operating temperatures are encountered.

6. Where it is desirable that the lubricant retain its position by virtue of its physical characteristics whether the machine is idle or in motion, such as in locomotive driving journal lubrication.

In all cases of relatively high speed, or wherever the oil can be effectively applied and retained by the bearing, grease lubrication should not be used unless other exceptional conditions warrant it, inasmuch as bearing temperatures and power consumption will be increased. Nor should greases ever be used where contact with steam may be possible and the exhaust steam is returned to boiler feed. The type of equipment available for feeding greases to the parts to be lubricated will also be a factor in determining when and where to use such lubricants.

In selecting a grease for any particular service, the melting point is usually taken as the governing characteristic. For instance, cup greases are designed for compression grease cups or pin cups on bearings where little frictional heat is necessary to make the lubricant flow. Where investigation shows the operating temperature to be relatively high, the melting point of the grease used should be proportionally higher. Under extreme pressure and temperature conditions as in railroad locomotive service a harder grease which can be applied in cake form to the bearing would be necessary.

Usual Tests for Greases

While there are a number of laboratory tests that can be made to determine the quality of any greases, essentially the melting point, or the temperature at which the grease begins to flow, will be the only one that the user can apply. The melting point will be an indication of the lubricating efficiency of the grease, knowing the operating temperatures of the parts whereupon it is

to be used. While there is no doubt that other tests might interest the engineer, he normally could make but few of them with any accuracy; therefore he must rely upon it that he is purchasing from a dependable manufacturer.

Melting point is found by coating a thermometer with the grease to be tested and then suspending it freely in an empty test tube, which is immersed in light oil. This oil bath is then gradually heated at the rate of 5 deg. F. per min. and the temperature observed. When a drop of grease forms on the end of the thermometer and falls to the bottom of the tube, the temperature is noted as the melting point of the grease.

It is evident from the foregoing that grease lubrication is governed by quite a number of factors and should be especially treated from an operating viewpoint. There is no doubt but that the lubricating value of grease, regardless of how carefully it may be manufactured, is limited to what might be called extreme conditions of operation and construction. Greases are not advisable for general all around lubrication, and their choice and usage should be decided upon only after consultation with lubricating engineers qualified to make recommendations by virtue of their experience in both the fields of machinery and lubrication. When greases are deemed necessary lubricants, due consideration of their properties, advantages and disadvantages will be most beneficial in deciding on the grades best adapted to the work in hand.

From the point of view of manufacture, the proficiency of the chemist and the skill of the grease maker are the governing factors. Once the composition has been determined it is a comparatively easy matter for anyone to make a substance that could be termed grease, though it would in all probability be dull, lumpy, and without lustre. Here is where the skill and judgment of the chemist and grease maker enter into the problem, if we are to produce uniform batches which are bright, lustrous, absolutely smooth and immune to lumpy separation, regardless of time or storage conditions.

Economical Use of Steam in a Sugar Refinery

FOR MAXIMUM ECONOMY IN OPERATION THE HEAT BALANCE BETWEEN HIGH AND LOW PRESSURE SYSTEMS MUST BE CAREFULLY MAINTAINED. BY C. C. BROWN

ONE OF THE major items in the cost of refining cane or beet sugar is the cost of the fuel burned for the generation of steam and electric power. Of the three largest items of expense, namely labor, fuel and containers, the outlay for fuel probably ranks second, with the labor first and containers third.

This being the case, an intelligent control of the use of steam and electric power in the operation of a refinery offers one of the most prolific opportunities for the exercise of economies and the accomplishment of a saving in the entire plant. This is especially true where the steam is generated at a high pressure, utilized for the operation of turbo-generators, prime movers, pumps, etc., and the exhaust of these appliances used for the heating and boiling of liquors, syrups, juices, sweet-waters, water, etc.

From the standpoint of fuel economy the modern sugar refinery, and in fact any plant where steam is used to any great degree in the process of its operation, to be run efficiently, must be so controlled that its heat losses are maintained at an irreducible minimum. Such a plant, where the live steam is used for the generation of power as well as the operation of engines, pumps, etc., and the exhaust utilized for heating and boiling purposes, must be maintained in a state of constant balance as between the amount of steam, both live and exhaust, generated and the amount utilized. In other words, at no time should there be produced more exhaust from the turbines, pumps, etc., than can be efficiently and economically utilized for the heating and boiling processes. As a matter of fact, it has been found that it is far more satisfactory from every standpoint to have a slight deficiency of exhaust that can be made up by the injection of a small amount of live into the exhaust than to have a surplus of exhaust which necessitates the blowing of a portion of it to the atmosphere. All such exhaust blown to the atmosphere if, of course, a direct loss.

Such is the nature of the refining of sugar that the various pieces of apparatus utilized in the process are large and widely separated. As a consequence of this condition, a large portion of the apparatus itself and the connecting steam lines are subject to large radiation losses. These radiation losses in many cases amount to some 10 to 15 per cent of the total steam generated. Great care should be taken to insulate properly all steam, liquor, syrup, hot water and other lines that carry heated liquids, as well as all portions of refinery apparatus in which hot surfaces are exposed to the atmosphere. Too many instances exist where inferior or inadequate insulation is improperly applied, and once in place is allowed to remain undisturbed under the false impression that it is performing its duty satisfactorily. Attention should also be directed toward affording the proper protection to correct an adequate insulation that it may remain free from abrasion and injury.

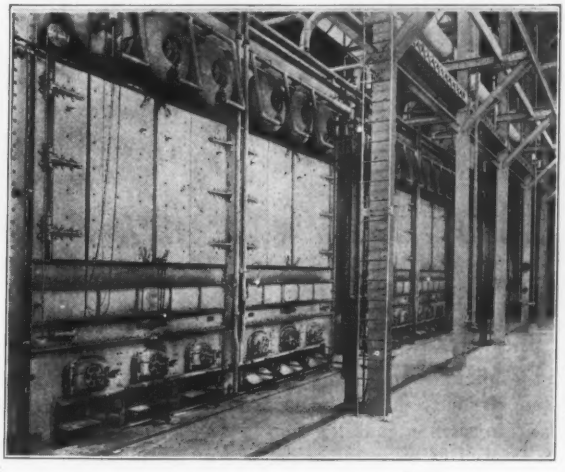


FIG. 1. STEEL INCASED, OIL FIRED, AUTOMATICALLY OPERATED BOILERS

Many times considerable latitude is possible in the choice of a location of a piece of apparatus being installed. In such cases, much thought should be given to the possible sources of steam supply, with the idea of eliminating long and unnecessary runs of pipe with their consequent radiation losses. Ventilation is a necessary factor in any plant; but excess draft and cold air blowing upon steam lines or steam apparatus not only causes increased radiation but is detrimental to the apparatus as well.

All installations of steam lines should be made with a liberal idea of line capacities. In too many instances, lines are installed to meet present needs only, with capacities barely sufficient to supply steam to apparatus in place, with no reserve capacity for future installations. Such short-sighted policy invariably results in excessive line drop, insufficient supply of steam, ultimate replacement of the line by one of larger capacity or the installation of additional lines. Live and exhaust steam systems should be laid out and installed in the plant in such a manner that a series of main arteries are located at or near the centers of distribution. Sub-arteries or branch lines should then be run to groups of steam consuming apparatus. All lines of the same pressure should be looped or tied in so that no dead ends exist, and all lines should be given a correct slope and properly drained.

This same liberal policy should be followed in the installation of electric power and lighting feeders. Excessive line drop and dangerous overheating can be obviated by the installation of main feeders of generous capacity located at or near the center of distribution with sub-feeders to local distributing panels.

Another source of heat loss, the evil of which is not generally recognized, is the practice of directly injecting live or exhaust steam into liquids for the purpose of heating them. In the case of the heating of sugar liquors and syrups, this practice of direct injection defeats its own purpose, in that it effects an appreciable dilution of the liquors. In order to bring these liquors and syrups back to the proper density for boiling they must necessarily be evaporated, which, of course, necessitates a further consumption of steam. In all probability the reason why direct injection has been resorted to in many cases has been the difficulties encountered in preventing the occurrence of leaks in closed heating coils in tanks. It is, however, perfectly feasible so to design and install such heating coils of copper pipe with brazed joints in the straight runs, long sweep bends with liberal allowance for expansion and contraction, and with the proper drainage, that they will not develop leaks for long periods—and it has been done.

In any sugar refinery, much heat is lost in the condenser water from vacuum pans and evaporators and from the enormous amount of hot water that is used to wash the filter bone char. In up-to-date plants a large percentage of this heat is recovered through the use of double coil heat exchangers. By the use of these exchangers, the hot waste water is passed through the inner coil and the water to be heated is passed in the opposite direction through the outer coil. Some idea of the amount of heat that is lost through these waste waters may be had when it is stated that for a refinery of 2000 T. capacity of refined output per 24 hr., there is discharged as waste waters some 10,000,000 gal. of salt water per 24 hr. which is heated in the pan and evaporator condensers from a temperature of 60 to 116 deg. F. Also there are some 3,000,000 gal. of fresh water which is heated from 60 to 212 deg. F. per 24 hr., about 2,500,000 gal. of which is used for washing the char from the bone filters and is discharged as waste water. When it is considered that all of this heat is furnished from the steam and indirectly from the fuel, it is readily seen that a huge saving of fuel is possible through the use of a system of heat exchangers.

The boiler house or steam generating portion of the

FIG. 2. GROUP OF THREE 1500-KW. TURBO-GENERATORS

refinery contains ten 600-hp. Babcock & Wilcox water-tube boilers equipped with Green fuel economizers. These boilers, shown in Fig. 1, are steel encased, oil fired and automatically operated. There are also in the plant four 300-hp. Stirling, four 250-hp. Babcock & Wilcox, and 14 horizontal return tubular Kilby boilers. Steam is generated at two pressures; 150 lb. from the 600-hp. boilers is carried in one header and 100 lb. from the remaining boilers in the other. An automatically operated butterfly valve delivers a portion of the 150-lb. steam to the 100-lb. header when the demand upon the latter exceeds the capacity of the smaller boilers. Steam from the 150-lb. header is supplied to three 1500-kw., 480-v., 60-cycle, horizontal Curtis turbo-generators, Fig. 2. These turbines are non-condensing and exhaust against a back pressure of 10 lb. into the exhaust steam system.

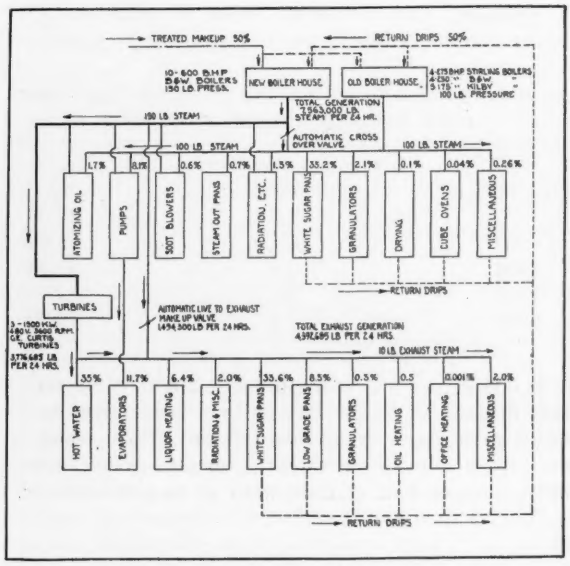


FIG. 3. DISTRIBUTION CHART FOR LIVE AND EXHAUST STEAM

Steam from the 100-lb. header is utilized in vacuum pans for the boiling of sugar liquors and syrups and in reciprocating pumps for the handling of sugar liquors, syrups, sweet-waters, hot and cold water and also for the pumping of fuel oil. These pumps also exhaust into the exhaust steam system against a back pressure of 10 lb.

Steam for the exhaust header is then used for the evaporation of sweet-waters in the evaporators, for the boiling of low grade and remelt liquors and syrups in vacuum pans, for the heating of water in the hot water tanks, for the heating in tanks of all liquors, syrups, sweet-waters, etc., for the heating of the granulators and for all incidental heating. All possible drips or condensation from the vacuum pans and tanks are returned to the boiler house as feed water for the boilers. There is installed between the 150-lb. steam header and the exhaust steam header an automatically operated reducing valve. Should the supply of exhaust steam from the turbines, pumps, etc., at any time become insufficient to satisfy the demand for exhaust steam, a portion of the 150 lb. steam will be bypassed through this reducing valve into the exhaust steam system.

Distribution of live and exhaust steam in this refinery is shown in the chart, Fig. 3, upon which is indicated the percentages of the total steam generated that is used for each purpose. The big problem in this plant as in all modern refineries, is to maintain the correct steam balance between the production of live steam and the utilization of live and exhaust steam so that no part of the exhaust steam will be blown to the

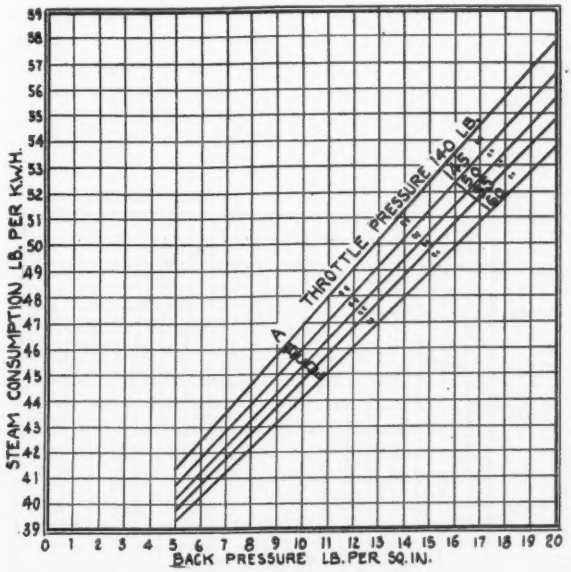


FIG. 4. STEAM CONSUMPTION FOR VARYING CONDITIONS OF INITIAL AND BACK PRESSURE

atmosphere. It can be readily appreciated that in order to accomplish this condition the electric power demand, the live steam demand and the exhaust steam demand must all three be so manipulated as to be in balance at any given refinery output rate. The apparatus at this plant is so connected that either live or exhaust steam may be used in certain portions of it, such as vacuum pans, heating coils in tanks, cube ovens, auxiliary heating apparatus, etc., all of which is equipped with the proper safeguards for such alternate operation. With such arrangement, the system is flexible and readily adaptable to regulation for the purpose of steam balance.

The principal source of exhaust steam is, of course, the turbo-generators. These turbines, when originally installed, had a guaranteed steam rate of 42.7 lb. of steam per kilowatt-hour at full load (1500 kw.), when operated against a back pressure of 10 lb. and with a throttle pressure of 150 lb. Figure 4 shows the variation of this steam rate with variation of initial or throttle pressure and back pressure. With a constant initial throttle pressure of 140 lb. per sq. in., the steam demand for 1000 kw. against a back pressure of 5 lb. per sq. in. is 41.4 lb. of steam per kilowatt hour, whereas if the back pressure is raised to 20 lb., the other conditions remaining the same, the steam demand is increased to 58.3 lb. per kw.-hr. It will also be noted that with a constant throttle pressure of 140 lb. and a constant back pressure of 10 lb., the steam demand varies from 42.7 lb. per kw.-hr. at full load to 50.2 lb. at half load.

From this it is evident that for the most efficient and economical operation of these turbo-generators, the

initial or throttle pressure must be maintained at a maximum, the back pressure at a minimum, and the load maintained as near as possible to the full load rating on each machine. With proper cooling and ventilation these machines have been operafed at the rate of 1850 kw. There are other factors of refinery operation, even more essential than the operation of the power plant, which must be taken into consideration and which determine in some degree the point at which the back pressure shall be maintained. For instance, the higher the back pressure, that is, the higher the pressure in the exhaust system, the more effective is its use for the purposes of heating and boiling liquors, syrups, etc. A great deal of experimentation has been carried on at the plant in question and as a result the pressure of

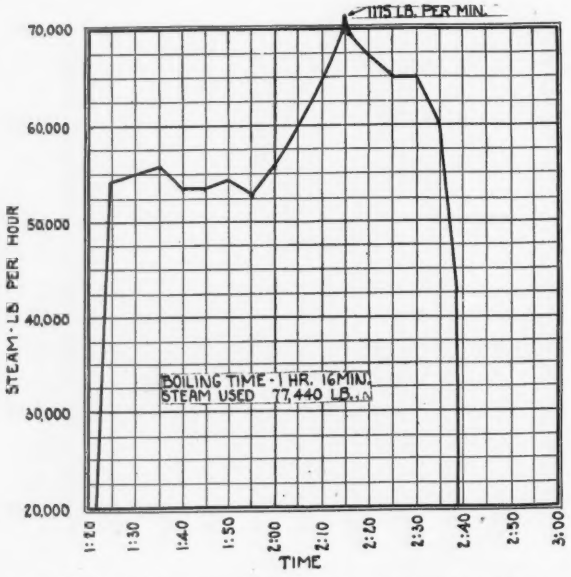


FIG. 5. STEAM REQUIREMENTS OF A VACUUM BOILER

the exhaust steam system has been set at 10 lb. per sq. in., as it has been demonstrated that this pressure was the most satisfactory from the standpoint of the refinery as a whole.

While on the subject of these turbo-generators, it might be stated that as at first installed they were equipped with bronze buckets in the steam rotor. After a period of some 6 mo. operation the steam rate of the turbines having greatly increased, the machines were taken down for a complete examination and overhauling. Such examination disclosed the fact that the bronze blades or buckets were badly eroded and also corroded to some extent. This was evidently due to wet steam; it was almost impossible to prevent the steam from carrying some moisture, due to the fact that the steam demands of the vacuum pans were heavy and erratic. The bronze buckets were immediately replaced by buckets of monel metal, which after an operating period of some 2 yr. showed scarcely a sign of wear or corrosion.

As originally installed, the turbine governors were operated by steam pressure. After some months of operation, difficulty was encountered with the governors sticking. A change was made in the medium for operating the governor piston, the steam being disconnected and the bearing oil system connected in its place. After this change the governors worked satisfactorily and evenly.

Wet steam is an evil that is hard to overcome in a sugar refinery for the reason that the steam demand is fluctuating. The putting on and taking off of large vacuum pans tends to produce wide variation and peaks which occur abruptly and at short intervals. The character of these sudden demands for steam is shown in Fig. 5, which is a chart showing the measured demand of a "strike," or boiling cycle of a 14-ft. coil vacuum pan taken under actual test. During these test observations the steam consumed by the pans was measured by flowmeters.

The pan from which the chart shown was taken holds 21,000 gal. of liquor which is equivalent to 80 T. of sugar and has an effective heating area of 1400 sq. ft. It took 1 hr. and 16 min. to boil the strike to grain and in so doing consumed 77,440 lb. of live steam at 60 lb. pressure. The maximum steam demand was 1175 lb. per min. or 70,500 lb. per hr., and jumped from zero

TABLE I. STEAM AND POWER REQUIREMENTS FOR VARIOUS DAILY RATES OF OUTPUT OF PRODUCT

Tons Sugar	Steam Consumption 1,000,000 lb.	Kw.-Hr. Generated
0	3.2	29,000
500	4.5	39,000
1000	5.8	49,000
1500	7.15	59,000
2000	8.4	69,000

to 54,000 lb. per hr. during the first 2 min. of operation. This demand of 54,000 lb. per hr. is equivalent to the entire rated capacity of three of the 600-hp. boilers in the first 2 min. of operation. Imagine what happens when three or four of these pans go on simultaneously.

The vacuum pan installation in this refinery consists of ten 14-ft. pans similar to the one described, and four 10-ft. pans. With this installation, it is obvious that if several of these pans are allowed to go on or off at the same time the effect on the boiler house is serious. In order to avoid this, a system of bells and signal lights has been installed whereby the boiler house is notified immediately preceding such action. In addition to this precaution a boiling schedule has been arranged whereby the pans are put on and taken off at given intervals consistent with the general pan floor operation. As a result of these precautions it seldom happens that more than one or two pans are either put on or taken off at the same time.

In the operation of vacuum pans, evaporators and heating tank coils, there is an ever-present chance for heat loss and inefficiency unless the steam coils of this apparatus is kept clean and free from scale. This scale is a solidified form of the gums that are in sugar solutions and also a deposit of the calcium carbonate that is in the water in them. The scale is generally removed by boiling out the apparatus with acid and then soda solutions.

The exhaust steam system which supplies steam for operating vacuum pans, evaporators, hot water tanks, liquor heating tanks, granulators, driers, cube ovens, etc., is so regulated that the exhaust steam pressure is maintained practically constant at 10 lb. per sq. in.

Should the demand fall off abruptly so that the exhaust steam pressure would tend to rise, it is prevented from rising above 14 lb. by an automatic multiple port relief valve. This valve is set at 14 lb. and relieves the pressure by discharging to the atmosphere.

In order that sufficient exhaust may be available for all demands, an automatically operated reducing valve opens when the exhaust steam pressure falls to 9 lb. and allows live steam to enter the exhaust system until the exhaust pressure rises to 10 lb., when it cuts off. In order that all steam demands, both live and exhaust, may be as uniform as possible and that the smallest number of peaks be thrown upon the boiler house, all refinery operations are carefully watched and made as smooth as conditions will permit.

TABLE II. REPRESENTATIVE LOG FOR ONE DAY'S OPERATION

Date	June 22, 1922
Raw sugar cut in T.	2070
Net refined output in T.	2024
Steam generated, lb.	8,881,000
Electric power generated, kw.-hr.	69,000
Fuel oil burned, bbl.	1772
Chimney draft, in. water	0.95
Fuel oil burned, lb. per hr	24,143
Water to boilers, lb. per hr.	370,042
Water blown off, lb. per hr.	7000
Water evaporated, lb. per hr.	363,042
Temp. feed water leaving economizer, deg. F.	238
Temp. feed water entering economizer, deg. F.	187
Temp. rise through economizer, deg. F.	51
Temp. boiler feed water, deg. F.	238
Total equiv. evap. F. & A. 212 deg., lb. per hr.	370,839
Equiv. evap., lb. water per lb. oil	15.3
Steam to burners, lb per hr.	4905
Per cent of steam to burners	1.35
Factor of evaporation	1.019
Net efficiency of boilers, per cent	78.4
Number of boilers on line	17
Total boiler hp. developed	10,748
Per cent of rating	143
Temp. of flue gas leaving boilers, deg. F.	538
Temp. of flue gas leaving economizers, deg. F.	356
Drop in temp. through economizers, deg. F.	182
Average CO_2, per cent	13.1
Temp. fuel oil entering heater, deg. F.	86
Temp. fuel oil leaving heater, deg. F.	186
Feed water pressure, lb. per sq. in.	200

In the ultimate analysis the efficiency of operation of any plant is the cost of production of its output.

The power plant in this refinery furnishes all of the electric power for both lighting and motors. The lighting load alone requires some 300 kw., which is, of course, a unity power factor load. The motor load is fairly even and well diversified. There are in the neighborhood of 600 motors varying in size from 1 to 350 hp. These motors are in constant operation for 24 hr. a day and for six days a week. They are used for all sorts of refinery duty, pumping, scrolling, elevating, dragging, etc. The largest motors, 300 to 350 hp., are used for pumping water and for operating air compressors. A number of these large motors are of the synchronous type so that when operated with slightly over-excited fields are of material assistance in maintaining a high-power factor at the generators. At the time that the turbo-generators were first installed and there were only a few motors in operation, the power factor was at times as low as 60 per cent; however, with the addition of a large number of motors, the increased load on the motors, the installation of the synchronous motors, and the installation of an adequate static condenser, the power factor was raised to and is maintained at 81 per cent.

A good idea of the steam and electric power demand for a sugar refinery with a capacity of 2000 T. of refined output per 24 hr. may be had from Table I. These figures are an average for one year's actual operation and show respectively the steam and electric power requirements for the various tonnages of output. In this connection it will be interesting to note an actual log for one day's operation shown in Table II.

With oil at $1.00 per bbl. of 42 gal. (15 deg. gravity oil), the cost of producing 1000 lb. of steam is $0.32. This figure includes all costs chargeable directly and indirectly to the boiler house, fixed charges, depreciation, interest, insurance, maintenance, upkeep and operation. One reason that this figure is as high as it is, is that all of the water that is used in the boilers is hauled to the refinery in barges over a distance of 20 mi. and all of this water has to be treated chemically before it can be used. The cost of this water delivered to the boilers is $0.30 per 1000 gal. or $0.04 per 1000 lb.

The cost of generating electric power, which is substantially a by-product obtained through the reducing of the steam from high to low pressure before it is used for boiling purposes, is low. Charging all of the items that are properly chargeable against the generation of electric power, fixed charges for plant, depreciation, interest, insurance, maintenance and upkeep and operating expenses and then adding the cost of the difference in heat content between steam at 150 lb. and at 10 lb. pressure, makes a total generating cost of $0.005 per kw.-hr. This is, of course, contingent upon the supposition that all of the exhaust steam is used in the refining process, for it is self-evident that it would be impossible economically to operate non-condensing turbo-generators with water rates as high as 42.7 lb. per kw.-hr. in competition with power that could be purchased for $0.01 per kw.-hr.

One method of sealing boilers against air leakage used by the Iowa Railway & Light Co. is to permit the boiler to operate approximately six weeks so as to allow the brickwork to develop any cracks that it may. It is then given a heavy coating of Johns-Manville boiler tite, a mixture of tar and asbestos. Old cut nails are driven into the brickwork at different points and chicken fencing secured to these. This is then plastered over with a coat of Johns-Manville No. 400 cement 1 in. in thickness. Over this is plastered a half-inch coating of Johns-Manville No. 400 cement mixed with a small amount of Portland cement so as to trowel to a smooth and finished surface. When this is thoroughly dried, it is given a coat of glue and then canvas glued on to this. The whole covering is then given a heavy coat of red mineral paint in linseed oil. This has been found to be a satisfactory method of sealing.

Air Preheater Types and Application

REVIEW OF BRITISH ATTITUDE TOWARDS BENEFITS DERIVED FROM USE OF PREHEATED AIR FOR BOILER FURNACES. BY JOHNSTONE TAYLOR

FOR SOMETIME past, attention has been given to the question of supplying boiler furnaces with hot air. The application of this method of increasing efficiencies is evidence that engineers are at last aware that the employment of methods making for the highest efficiency in the boiler room is long over due.

Heat carried away in the flue gases represents the main source of loss in connection with steam boiler operation. The adoption of forced and induced draft

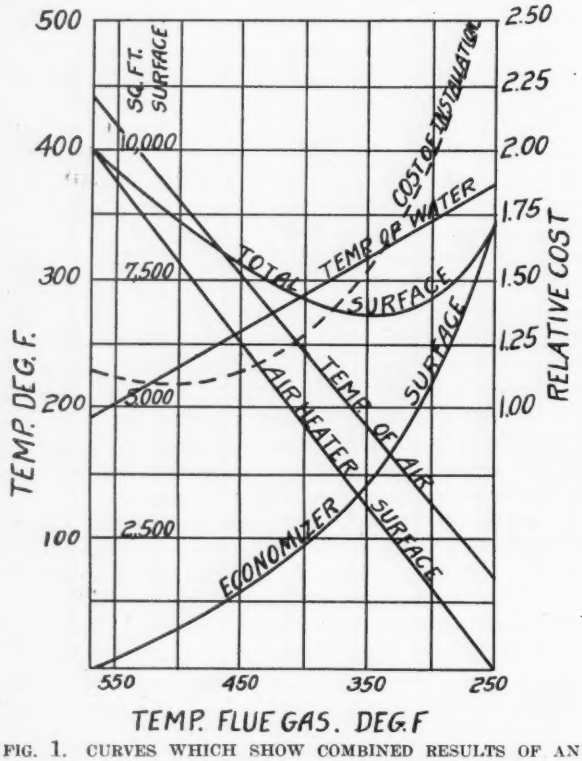


FIG. 1. CURVES WHICH SHOW COMBINED RESULTS OF AN ECONOMIZER AND AN AIR PREHEATER FOR WASTE HEAT ABSORPTION

has done away with the necessity for high flue gas temperatures to maintain natural draft. This has led the way to more close attention being paid to the recovery of waste heat. The economizer, although an essential part of a modern boiler plant, does not recover the maximum amount of available waste heat. Moreover, with high steam pressures the design of the economizer is becoming increasingly difficult. Steel economizers are subject to the difficulties of corrosion, and the cast iron type is considered to be rapidly nearing its limit with the high pressures now in vogue. With a properly operated boiler plant, the temperature of the flue gases after passing the economizer is approximately 400 deg. F. With forced draft this represents a considerable waste of heat, 10 per cent, in fact, of the available heat in the coal. Provided, therefore, that higher pressures do not altogether foretell the end of the economizer, the air preheater may be regarded as a good means of utilizing the excess of waste heat rather than as being a substitute for the economizer.

EFFECTS OF PRE-HEATED AIR

In view of the destructive effect of high combustion temperatures on the present design of furnaces, the use of pre-heated air is not at the moment regarded any too favorably; however, with furnace design modified to suit the new conditions, many engineers regard pre-heated air with favor. A large proportion of the energy of burning fuel is evolved as radiant heat, which will increase the rate of steam raising if it has direct access

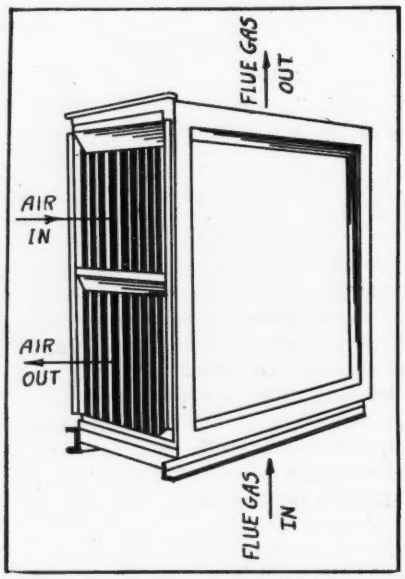


FIG. 2. THERMIX PREHEATER IN WHICH AIR IS CIRCULATED THROUGH ELEMENTS SURROUNDED BY THE GAS

to the tubes in place of being reflected back on the fuel by the furnace arch. Increase of furnace temperature means greater rapidity in the evolution of this radiant heat, and if it can be rapidly absorbed by the boiler tubes, the net furnace temperature will be little in excess of what it would be under the conditions of a cold air supply.

In the case of chain grate stokers, the arch is regarded as necessary for the proper ignition of low grade fuel, and the use of pre-heated air involves heavy wear and tear on that arch. It is necessary, therefore, either to shorten the arch or to do away with it altogether. This latter suggestion seems to be feasible when supplying the furnace with pre-heated air.

There is also the question of durability of the grate material, but this is not generally regarded as serious in view of the extended use of "Calorized" iron for this purpose. If the furnace difficulties can be overcome the pre-heater question resolves itself into one of designing an efficient heater and utilizing it either in preference to an economizer or in conjunction with a smaller economizer than would otherwise be necessary. It must be

admitted that an air heater is both easier and cheaper to install than an economizer, especially with water tube boilers. It should be borne in mind, however, that the economizer has reached a very high state of perfection and that the air pre-heater is as yet in the experimental stage.

Benefit of Low Flue Gas Temperature

It is well known that in order to reduce heat loss via the chimney a high percentage of CO_2 must be obtained.

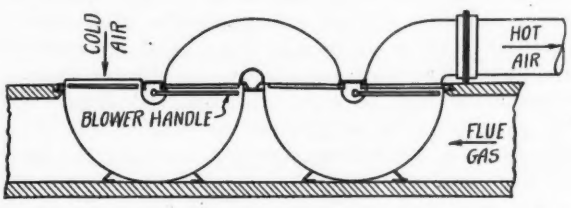


FIG. 3. STEAM SOOT BLOWER MOUNTED ON TRUNNIONS IS A FEATURE OF THE PREHEATER

If p = the percentage of CO_2 by volume, T = the temp. of the flue gas in deg. F., and t = the temp. of the atmosphere in deg. F., then the sensible heat H which

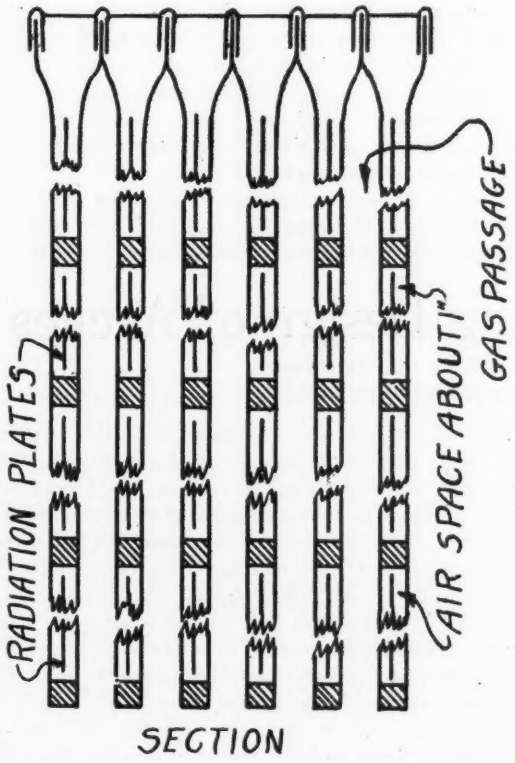


FIG. 4. SECTION THROUGH USCO PREHEATER ELEMENTS

represents chimney loss can be calculated by the formula

$$H = 0.37 \frac{T - t}{p}$$

In a badly operated plant with T = 600, t = 60 and p = 6 per cent

$$H = 0.37 \frac{600 - 60}{6} = 33.3 \text{ per cent}$$

In a well operated plant provided with either an economizer, an air heater or both, for reducing T to say 300 and having p = 10 per cent, then

$$H = 0.37 \frac{300 - 60}{10} = 8.88 \text{ per cent}$$

Theoretically, the economizer should be able to effect this saving as well as an air heater, but by virtue of its construction air leakage tends to reduce the theoretical saving.

From a heat recuperation point of view, the air heater could at much lower first cost prove at least as efficient

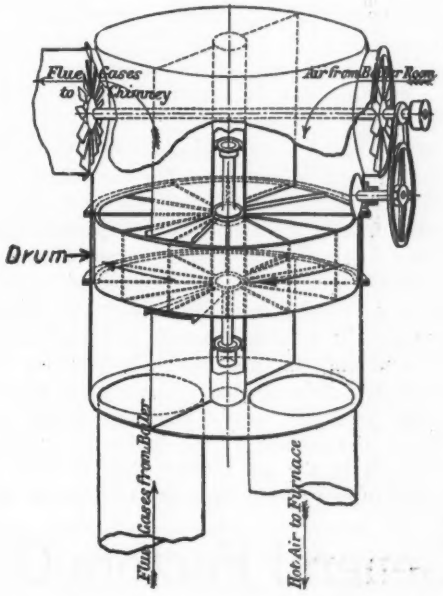


FIG. 5. PHANTOM VIEW OF LJUNGSTRUM PREHEATER

as an economizer. The feed water could be efficiently heated by the generally accepted system of bleeding the turbines. Where a considerable drop of heat is looked for, say exceeding 300 deg. F., it will usually prove, as before suggested, that the most economical course lies in the installation of a small economizer to complete the heating of the feed and a pre-heater to complete the absorption of the heat in the flue gases, the effect of such an arrangement is shown graphically in Fig. 1.

Opinion of the British Underfeed Stoker Company is to the effect that heated air produces a higher furnace temperature and a more energetic oxidizing effect upon the hydrocarbon gases, which are so difficult to burn when cold air is used. With heated air, on the other hand, the flame is bright, clear and almost smokeless, and with inferior coals containing much moisture this effect is extremely pronounced. It is also claimed that the heat losses due to an excess of air passing through a fire are diminished in proportion to the temperature of the air, for if the air entered the fire at the temperature of the escaping gases there would be no loss due to any excess

air over that required for the actual chemical combination with the fuel. This is regarded as an important point because, while a pound of carbon in coal requires according to theoretical considerations only about 12 lb. of air for its complete combustion, it is found in practice, that to insure the proper burning of coal without the formation of incomplete products of combustion, not less than 20 lb. of air are required and all this air has of necessity to be raised to furnace temperature.

Preheater Construction

One type of preheater known as the "Thermix" is of French design and is as shown in Fig. 2. The air to be heated enters the upper half of the heater box and becomes heated as it passes over and around the elements. The direction of air flow is reversed within the box and leaves just below its point of entrance. The flue gases pass vertically through the heater box inclosure.

Another type of preheater known as the "Usco" heater is manufactured by the British Underfeed Stoker Co. This heater is shown in Fig. 3. The elements, shown in section in Fig. 4, consist of a semi-circular sheet steel plate box built up in sections. The air passes in a semi-circular path through the elements and the exhaust gases pass outside the elements in a parallel direction. The heater is cleaned by a steam blast which is introduced through a trunnion pipe connected to the steam supply by a swivel joint. By means of a handle, the trunnion can be revolved so that the perforated pipes which extend into the gas spaces between the elements can sweep the whole surface. This type of heater, built on the unit principle, can be placed in almost any position within the setting of the boiler in preference to being erected in the main flue. This reduces the cost involved in providing air ducts and enables the flue gases to be supplied to the heater at their maximum temperature.

Gas spaces of the Thermix type are blown out periodically by an air jet while the Usco design makes use of steam. In both cases, the deposit of soot impairs the efficiency of the heater until it is removed. In the Ljungstrum design, shown in Fig. 5, soot deposit does not have any serious effect upon heat transference and, moreover, soot accumulations can be very rapidly removed. As shown by Fig. 5, fresh air is drawn by a fan into the upper portion of a vertical cylindrical casing which is divided into two parts by a vertical partition. Air is confined to one side of the partition and passes downward to a similar semi-circular chamber through the body of a porous cylindrical drum. The flue gases from the boiler traverse the other half of the apparatus in the reverse direction, entering the lower chamber and passing upward through the drum to the upper compartment where they are exhausted to the stack by another fan.

Rotation of the drum is continued so that the portion heated by the flue gases is constantly passing to the other side of the apparatus where it gives up its heat to the cold air. Similarly, of course, the cool part of the drum is continually returning to be reheated by the flue gases. The porous drum is built of thin sheet steel and divided into sectors by radial plates which serve as stiffening spokes. Each sector is packed with a number of thin sheet steel plates which are separated by small channel strips welded in place. The construction is such as to offer a minimum of resistance to the passage of gas, yet brings both gas and air into intimate contact with a large heat absorbing surface.

It may be stated that the application of air preheaters at present is mainly connected with high duty boiler installations in the larger steam power stations.

General Factors Governing Design of Arches

An Analysis of the Action of Arches and the Factors Involved in Their Design. By Zuce Kogan

ARCHES, or other arrangements of brickwork above the fuel bed in furnaces, are installed for the purpose of heating the fuel underneath it previous to ignition. The value of such an arch, then, is dependent upon the quantity it can furnish to the fuel bed. In order to determine the effectiveness of an arch, it is necessary to take into consideration three factors:

1. The temperature of the arch.
2. The amount of heat collected by the arch.
3. The amount of heat from the arch reaching the fuel bed.

Temperature of the arch depends upon the kind of fuel used on the height of the arch above the fuel bed.

The amount of heat collected by the arch depends on the shape and kind of material of the arch, while the heat as reaching the fuel bed depends on the distance between the fuel bed and the arch, and also on the particular shape of arch. For this reason, in order to find more definitely the effect of arch or the general factors governing its design, it becomes important to consider each of the foregoing items separately.

In considering arch temperatures, the length of flame is an important factor, and this is to some extent dependent upon the kind of fuel used. Although the length of flame may be increased or decreased with the manner of using the fuel in combustion, the flame length depends on the volatile matter of the fuel. Any flame may be said to have different temperatures at different distances from the fuel bed, in the same way that we suppose the flame of a candle to be lowest in temperature at its generating end and highest at the other end. Fuels may have short or long flames, even much longer than the distance between the arch and the fuel bed, this obliging the flame to bend and turn itself to the bridge-wall passage.

With the bending of flame in this way, the temperature is lower than at the final end. To demonstrate that these assertions are true, it will be interesting to refer to the theory that the flame is a path of luminous gases which have been incompletely burned, while near the end of the flame is the intense combustion of the combustible gases. This theory is to be preferred to the theory which holds that the flame is the combustion

of combustible products, and that the end or termination of the flame represents the cooling of these products.

Should the production of flame depend upon the latter theory, the end of the flame would be much duller in appearance than the central portion, due to the constant cooling of the elements while travelling. Observation, however, indicates just the contrary, the flame being brightest at the extreme end. This denotes that combustion is most intense at the final portion.

The first theory does not deny that there exists a certain amount of combustion within the length of flame before reaching the final end, but it does not credit to the bright portion that the combustible products are in process at combustion. For the same reason we cannot credit the luminous quality of a heated metal to be due to the oxidation of some carbon elements, because an electric lamp or a radio vacuum tube contains no air and still there is light. For this reason, it is clear that the theory that flame is combustion is not sufficiently true, while the other theory is much more fundamental.

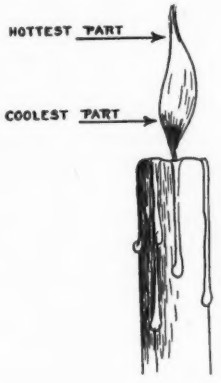


FIG. 1. THE UPPER PORTION OF A CANDLE FLAME IS THE HOTTEST

With the second theory, it will mean that the carbon and some of the oxygen is highly heated and should they mix they may burn to CO or CO_2 at any distance within the flame, while the most ignition is near the end of the flame where more is entering into combustion. From this it may be concluded that at the farthest point in the flame more of the air is present and at the final end of the flame most of the combustion takes place. This indicates that the temperature of the flame is successively greater as the distance from its generating end is farthest.

Referring again to the tendency of a long flame to bend itself towards the bridge wall, and to the fact that it is not at the bend that the greatest temperature exists, but at the absolute final end of the flame that is hottest, it is obvious that the arch will be heated according to the temperature of the flame near it, that is, according to the temperature at the bend of the flame.

Temperature of the Arch

Since the arch forms a part of the combustion chamber it abstracts heat to equalize in temperature with the furnace, therefore the temperature of the arch depends on the furnace temperature near it. This, as stated above, will depend on the kind of fuel and the length of flame and height of arch from the fuel bed. Having assumed that the flame has different temperatures along its length, it follows that the different lengths of flame may give different temperatures, and the portion of flame length near the arch will determine the temperature of the arch.

In the same way, with a given length of flame, the greater the distance between the fuel bed and the arch, the higher will be the temperature of flame heating it,

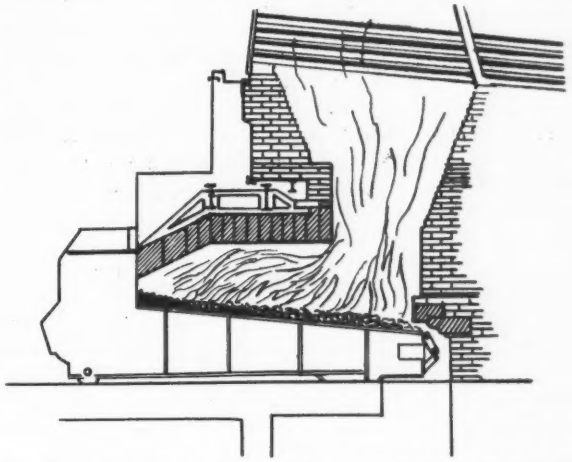


FIG. 2. TYPICAL ARCH, SHOWING BENDING OF FLAME IN FURNACE

and the hotter will be the arch. For this reason, the height of arch is the second factor that determines the arch temperature.

Collection of Heat

In any heating apparatus the power of heating depends on the temperature and the heat content. The latter fact is an important factor to be considered with the heating effect on the fuel. The more heat the arch can collect, the more it has for radiation and the better will be the heating. To determine the amount of heat it is possible for an arch to accumulate for radiation, it is necessary to consider the shape of the arch and the kind of material it is made of.

Considering the shape, this is of importance due to the fact that its area varies accordingly, i. e., it determines the area of the arch with a given section of furnace. For example, a circular arch installed with the furnace will have a greater area than will a flat arch. The flat arch has the smallest possible area. Other arches increase the area according to their particular shapes. The greater the area the greater will be its heat collecting power, and as a consequence the greater will be the amount of heat that it can radiate to the fuel bed.

With respect to material it may be said that it is one of the physical properties of matter that heat may be absorbed more or less according to its nature. Some material will absorb much more heat without conducting it than others; i. e., it is a good absorber but a bad conductor. The latter is the kind of material most suitable for the construction of the arches, so that it may collect much heat (not conduct it) and radiate it whenever necessary.

It is of interest to mention that arches above the green fuel bed require a large heat storage capacity, because when a fresh charge of fuel is placed in the furnace, this charge will abstract its heat quickly and the arch would cool down quickly unless it had sufficient heat in storage.

Radiated Heat

Radiated heat reaching the fuel bed generally depends, as far as the furnace design is concerned, on the distance between the fuel bed and arch and on the shape of the arch. The distance determines the intensity or temperature and the shape determines the amount of calories as reaching the fuel bed.

Considering the distance, it is known that the temperature at any point away from the arch varies according to the law of inverse squares, therefore the greater the distance between the fuel bed and the arch the smaller the intensity of radiation. The effect of this law is considerable, as the heat radiated from an arch 3 ft. in height will radiate 1/9 of that radiated from one foot in distance. The shape of the arch governs to a great extent the projection of heat for a given fuel area. This must therefore be considered from the point of view of projecting area. The projecting area of a flat horizontal arch and an assumed horizontal flat fuel bed are equal. With an inclined arch, however, the projection of heat per area of fuel bed is greater and increases with the increase in inclination. On the other hand, a circular arch gives a much greater projection of heat per fuel area. This greater projection radiates more heat rays on the fuel and effects its heating to a better extent.

Comparing the Heating of Arch with That of Fuel

From the preceding it is obvious that by comparing the heating surface of arch with the heating surface of fuel, we have two factors that are concerned with both the arch and fuel. These are the shape and the height of arch. The shape has the same effect with the heating of arch as with the heating of fuel, but the height gives just the contrary effect with each of them. It means that in the latter case the temperature of the arch decreases with decrease in distance, while the temperature of the fuel due to reflected heat is decreased with increase in distance. This makes the height an important question that needs great consideration. In order to consider the effect of height on both fuel and arch heating, it becomes important to compare the relative effects.

Let us assume that the temperature of the fuel bed and the temperature at a point near the arch is 1800 and 2400 deg. respectively; this gives a difference of 600 deg. F. Taking the distance of the arch to the fuel bed as 2 ft. and for simplicity of demonstration let us assume that the difference in temperature of flame at one foot distance of arch is 600/2 or 300 deg. This shows that should the height of arch be reduced from two to one foot in distance the temperature near the arch will be 1800 plus 300 or 2100 deg. F., and the decrease in temperature due to the lowering of arch to one foot is about 12 per cent of the total.

Considering now the radiation from the arch on the green fuel bed, it is evident according to the inverse square law that the radiation from a two foot high arch will be one-fourth of that of a one foot high arch and the gain will be therefore 75 per cent. This shows that the distance with reference to heat radiation is a more important factor and is of greater influence on the fuel heating than distance with reference to the arch temperature. As far as the heating effect is concerned, therefore, the arch must not be very high, but the distance is also dependent upon factors governing the economical combustion of fuel.

Coke Shows High Efficiency for Domestic Heating

SINCE thousands of householders are now pondering the problem of next winter's fuel supply, the Department of the Interior calls attention to the results of tests recently made by the Bureau of Mines which demonstrate the high efficiency of by-product coke. Tests conducted by the Bureau at its Pittsburgh and Minneapolis experiment stations with different types of steam boilers suitable for heating 7 or 8-room houses recorded as high efficiencies with by-product coke as with anthracite. The efficiencies obtained with Pittsburgh and Illinois bituminous coal were 8 to 20 per cent lower than those obtained with coke.

Anthracite used in these tests was a mixture of egg and nut sizes and was considerably cleaner than that ordinarily obtained in the Pittsburgh market. The by-product coke tested at Pittsburgh was of domestic size, made from a mixture of several coals from the Klondike region near that city. The by-product coke tested at Minneapolis was of domestic size and made from eastern coal.

With the same attention to the fire, the Bureau of Mines found that coke gives much more uniform temperature than bituminous coal. In addition, coke is a clean fuel and makes neither smoke nor soot, an advantage difficult to express in exact figures. It is nearly as good a fuel as the domestic sizes of anthracite, and if anthracite is unavailable at reasonable prices, a by-product coke makes a good substitute.

Domestic fuel should preferably be clean and smokeless and should keep the house at an even temperature, with little attention to the fire. Anthracite, suitably sized, possesses these properties to a large degree and has been used for this purpose for a long time, particularly near the anthracite mines. Many thickly populated districts are so far from these mines, however, that anthracite can be obtained only at a high price, and the bituminous coal that is available is not so clean and requires more frequent attention to the fire to maintain a uniform temperature. By-product coke, in small sizes, is a good substitute for anthracite.

Condensed instructions as to proper methods for the burning of coke in house-heating equipment are given by the Bureau of Mines as follows:

Carry a deep bed of fuel; one about 18 in. thick gives the best results.

Use very little draft after the fire is started, and keep it always under control. The success of even heating depends on careful draft regulation.

Do not stir the fuel bed; clean the fire in the morning.

Use sized coke; ½ to 2 in. for furnaces, boilers and stoves; ½ to 4 in. for open grates.

Do not allow ash to accumulate in the ash pit.

Practical Construction of Alinement Charts---III*

A Study of Various Types of Charts for Various Purposes. By R. T. Livingston†

IN ORDER to illustrate further the method of construction of alinement charts, we will take up in turn the various ones which are illustrated in this article, each one of which is intended to designate one particular point of interest. Figure 1 illustrates a "Nozzle Discharge Chart." This chart is based on the common formula for nozzle discharge

$$Q = FK\sqrt{2 \cdot g \cdot h}$$

and checks with the table issued by the National Board of Fire Underwriters. On the left-hand scale is laid off head in feet, but the final divisions which are shown correspond to the head in feet multiplied by a factor for converting head in feet to pounds per square inch. Now the second scale is reversed in order to throw the answer to the right and though laid out to area in square feet it is marked in "diameter of nozzle in inches." This is an illustration of the procedure mentioned in the previous article of throwing the answer line to the right when the multipliers are fixed and definite and there is no need of interpolation. The method of use is obvious. The illustrative example shows that a nozzle 1⅜ in. in diam. under 80 will deliver 500 g.p.m.

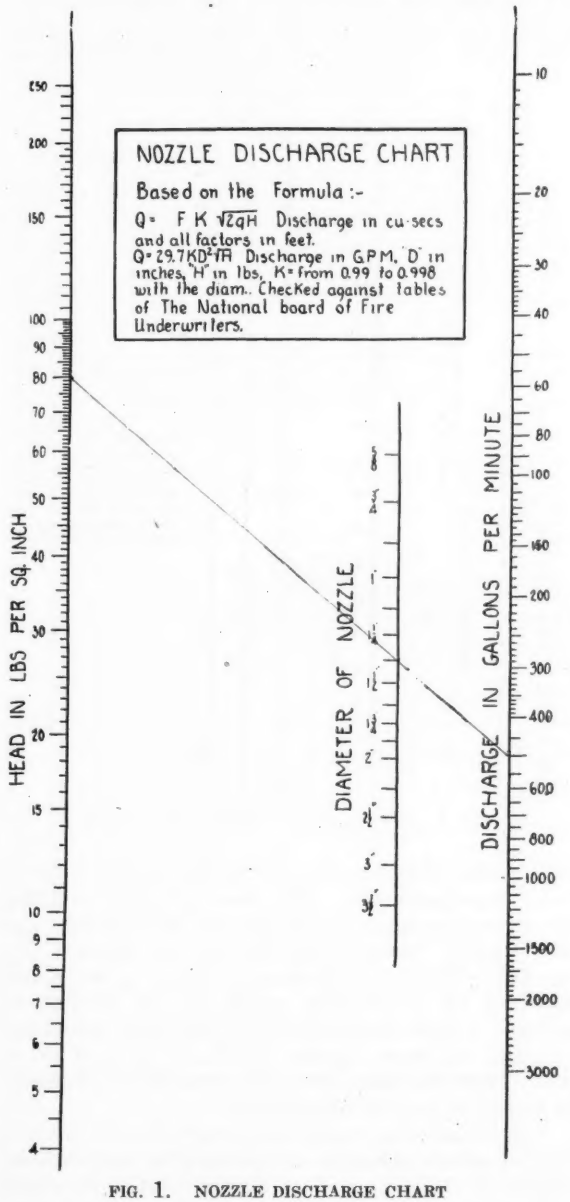

NOZZLE DISCHARGE CHART
Based on the Formula :-
Q = F K √2gH Discharge in cu·secs and all factors in feet.
Q = 29.7KD²√H Discharge in G.P.M. D in inches, H in lbs, K = from 0.99 to 0.998 with the diam.. Checked against tables of The National board of Fire Underwriters.
HEAD IN LBS PER SQ. INCH
DIAMETER OF NOZZLE
DISCHARGE IN GALLONS PER MINUTE

FIG. 1. NOZZLE DISCHARGE CHART

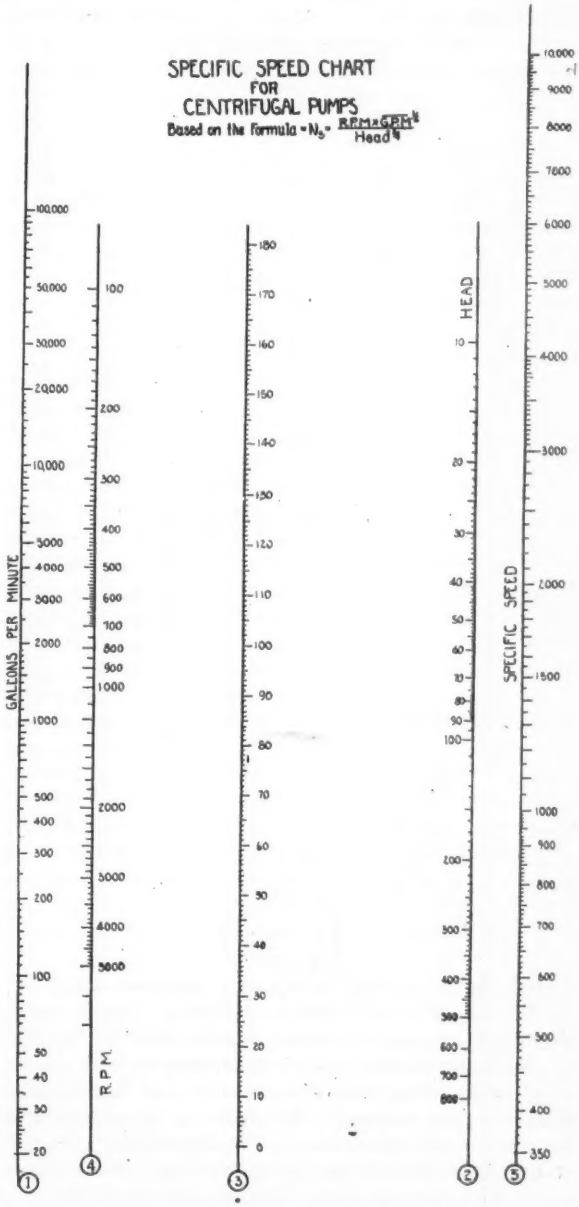


FIG. 2. SPECIFIC SPEED CHART FOR CENTRIFUGAL PUMP

* All rights reserved by the author.
† Hydro Mechanical Engineer, New York City.

Now that the construction and use of a simple five-line chart have been explained in the second article and other one shown in the first article, we will proceed to the construction of a chart for the "Specific Speed" of centrifugal pumps. The formula is:

$$N_s = \frac{\text{r.p.m.}\sqrt{\text{g.p.m.}}}{H^{3/4}}$$

thus introducing an equation which has both multiplying and division and also the raising of numbers to uneven powers. This factor bears the same relation to centrifugal pumps that specific speed does to hydraulic turbines. Even though it is not used as much as the former, it is nevertheless an excellent guide to the "type" of the pump. In this case, the formula was divided as follows:

$$N_s = (\text{r.p.m.}) \cdot \left(\frac{H^{3/4}}{\text{g.p.m.}^{1/2}}\right)$$

and the latter part of the equation was first solved thus getting rid of the odd powers. Note, on Fig. 2, that as there is a division, the second S scale runs in the opposite direction to the first and as the answer scale was desired large, it was thrown to the right and the revolution scale was also reversed. It is also to be noted that as the answer to the first division was not desired, that the S line is divided decimally and is used for reference only. The problem which illustrates the use of the chart shows 500 g.p.m. against 1000 ft. head at 1500 rev. gives a specific speed of 1060.

Two or more alinement charts may be joined together to form one large chart which will perform a whole series of correlated computations. It is often desired to figure current required at a given voltage to pump a certain quantity of water against a given head. Figure 3 illustrates a chart for such computations. The interesting part of this chart is the fact that the same line is used for a number of purposes thus cutting down the number of lines required. There are eight factors and only six lines. The use and construction is best illustrated by example. It is desired to pump 100 g.p.m. against 100 ft. head. Join these two points on line A and B respectively a and b. This gives us 2.52 water horsepower, on scale C at point s as the output of the pump. Connect this point with the assumed efficiency of the pump at point d on scale D, in this case taken as 80. Note that the efficiency is laid out on the right-hand side of scale A. Now continue along this line and read brake horsepower on scale Z = 3.2. This is the horsepower put into the pump shaft. Now the motor has a certain efficiency, say

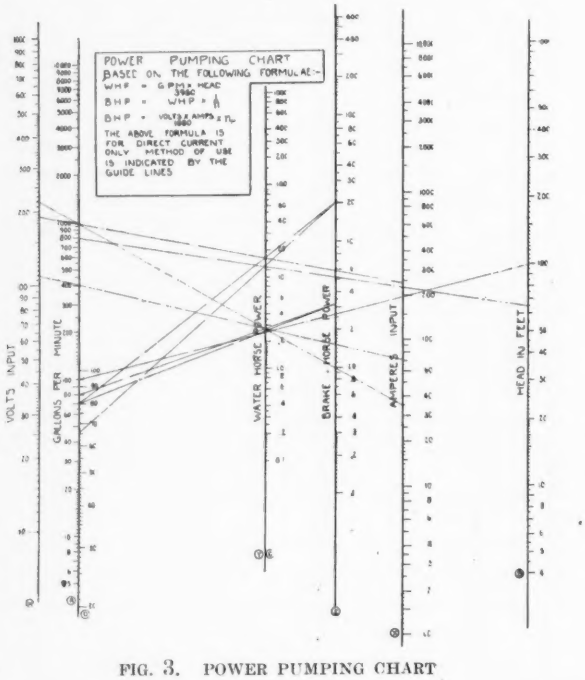

POWER PUMPING CHART
BASED ON THE FOLLOWING FORMULAE:-
THE ABOVE FORMULA IS FOR DIRECT CURRENT ONLY METHOD OF USE IS INDICATED BY THE GUIDE LINES
VOLTS INPUT
GALLONS PER MINUTE
WATER HORSE POWER
BRAKE HORSE POWER
AMPERES INPUT
HEAD IN FEET

FIG. 3. POWER PUMPING CHART

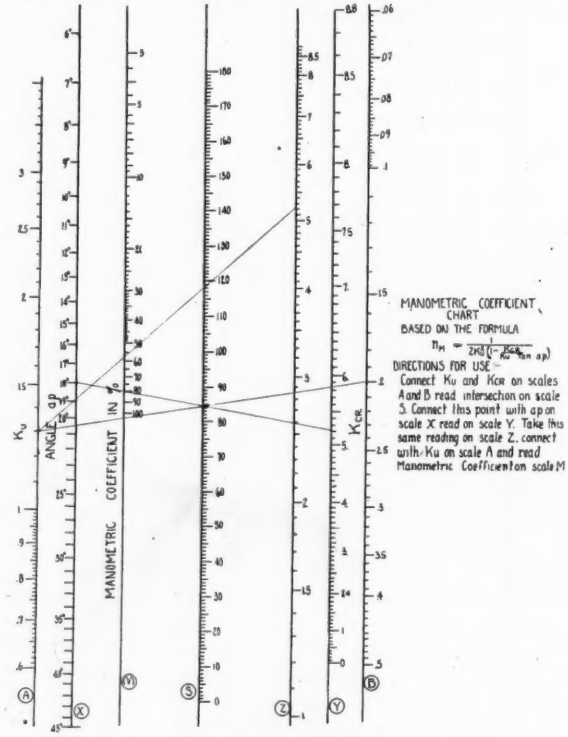

MANOMETRIC COEFFICIENT CHART
BASED ON THE FORMULA
DIRECTIONS FOR USE:-
Connect Ku and Kcr on scales A and B read intersection on scale S. Connect this point with ap on scale X read on scale Y. Take this same reading on scale Z. connect with Ku on scale A and read Manometric Coefficient on scale M
ANGLE OF
MANOMETRIC COEFFICIENT IN %
Ku
Kcr

FIG. 4. MANOMETRIC COEFFICIENT CHART

90 per cent. Connect 3.2 with 90 and read 2.75 on the water horsepower line. This does not mean anything, the water horsepower line in this case being merely used as a support. Connect this 2.75 with the assumed voltage 110 or 220 on line W and at g and g^1 on line X read 35.5 and 71, respectively, which are the amperes required. Another problem is illustrated which shows that to pump 800 g.p.m. against 64.5 ft., if we have 192 v., will require 245 amp., with the pump motor efficiencies as 66 and 80 per cent respectively.

All the charts given heretofore have been for the solution of simple equations of multiplying and dividing. Figure 4 illustrates a chart for the solution of a more complex equation and gives an idea of what is sometimes necessary if we wish to preserve straight lines. The "manometric coefficient" of a centrifugal pump is the theoretical hydraulic efficiency and is a term used in centrifugal pump design. Its value is given by the formula:

$$n_m = \frac{1}{2\,K_u^2\left(1 - \frac{K_{cr}}{K_u \tan a_p}\right)}$$

Where K_u is the ratio of the tip speed to the spouting velocity corresponding to head pumped against, K_{cr} is the ratio of the radial component of the velocity of flow to the spouting velocity and (a) the angle between the tangent to the wheel and the relative velocity of the

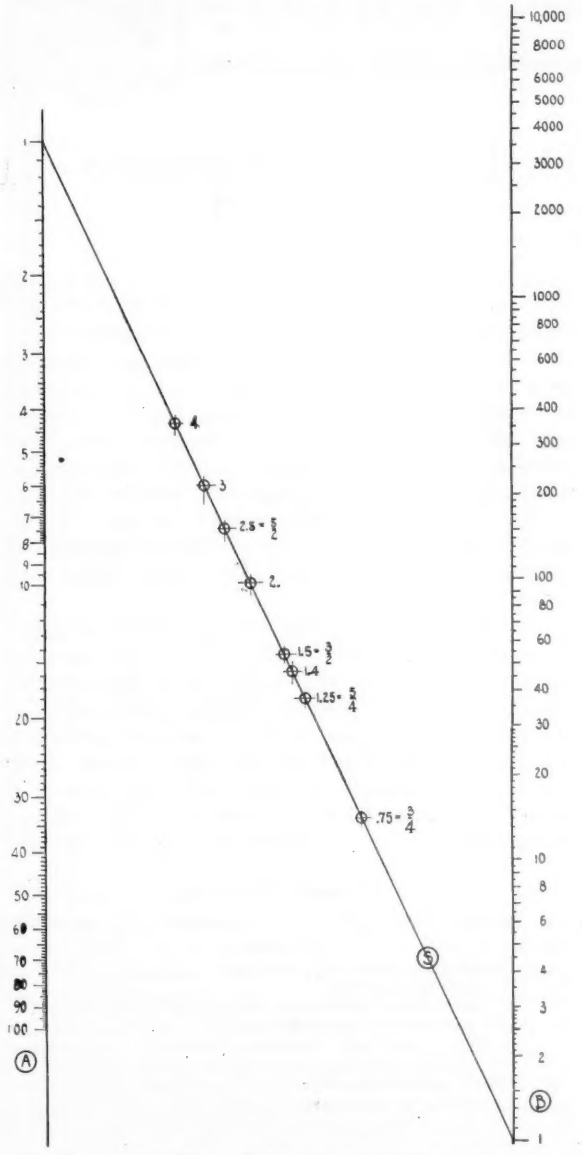


FIG. 5. ALINEMENT CHART FOR NUMBERS RAISED TO VARIOUS POWERS

water. In order to solve the equation, it was first put in the form

$$\frac{1}{n_m} = 2\,K_u^2\left(1 - \frac{K_{cr}}{K_u \tan a_p}\right)$$

and then the answer would appear as the reciprocal, but would be marked as the monometric coefficient directly. The first operation was the solution of $\frac{K_{cr}}{K_u \tan a_p}$ This was solved for and the answer line was marked as one minus this quantity, thus it is seen that scale Y is not laid off as a logarithmic line. Having obtained that, this reading was taken over to the next line and joined with the K_u line and the answer obtained. The solution of a problem is probably the best method of illustrating its use.

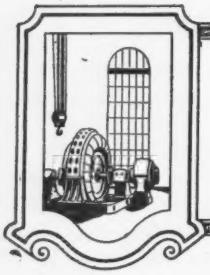
Assumed a value of $K_u = 1.3$, on scale A, join with an assumed value of $K_{cr} = 0.2$ on scale B and intersect line S at 84.5. Join this point with the assumed value of $a = 18$ deg. on scale X and read 5.23 on scale Y. Note that the angle is marked on scale X, actually the tangent is laid out. Then this value is taken on scale Z and connected again with K_u on Scale A. The intersection on scale M is 57 which is the desired monometric coefficient.

Figure 5 illustrates a chart which is designed to perform the operation of raising any number to any one of a certain number of powers or taking the same roots of numbers. The equation is X Z. This equation is of slightly different form from the others that have been solved and in consequence the chart is of slightly different form from the others. This form of chart is known as the "Z" chart and though it differs in name and slightly in form, the method of construction and use is exactly the same as the chart shown before. In this case, the two lines A and B were first laid out where desired and some construction was gone through to get the points of the support line.. If it had been desired, having determined three or four points, the support line might have been divided logarithmically; but this was not deemed advisable and only the more common powers were marked. If powers are desired take the number on the A scale, the power on the S scale and read the answer on the B scale; if roots are desired, reverse the process and take the number on the B scale, the root on the S scale and read the answer on the A scale. Numbers larger than those shown on the chart may be handled by merely adding the same numbers of ciphers to the number and to the answer.

From a study of the types of charts given in these articles and by a little practice in the construction of simple charts, there is no doubt that anyone who is able to do drafting and use a slide rule can make alinement charts. The principal things to remember are: first, be careful; second, be accurate; and last, but not least, mix a little brains and common sense with your pencil lines.

A DEFINITION of a successful business might be conceived as one where the economic reason for its existence is that it satisfies a legitimate and necessary human demand; that its policies are sound and fair and that its organization, comprising both men and management, believes heartily in those policies and is properly fortified, by inclination and training, to put them into practice with the result that the business runs continually; makes profits so that it can grow, and pays good wages so that its employes are content, thus eliminating stoppage of work, excessive turnover and dissatisfaction. —Charles R. Hook, vice-president and general manager American Rolling Mill Co.

ONE POUND OF STEAM used first in a steam engine or a turbine and then in a heating system will replace approximately 1½ lb. of steam required where the engine or turbine is run condensing and live steam is used in the heating system.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Transmission-Line Load Distribution Factors---II

APPLICATION OF LOAD DISTRIBUTION FACTORS TO TRANSMISSION LINE PROBLEMS. BY E. K. McDOWELL*

AS REGARDS THE application of load distribution factors to transmission line design, the general procedure outlined in the first part of this article may often be considerably abridged, or more or less loosely applied, depending upon the extent of the distribution system for which the aggregate demand is to be determined, and upon whether or not some of the larger loads are more or less indefinite—as, for instance, in connection with allowances made for expected future loads. Evidently, if such allowances are arbitrary in character, rather approximate methods will do well enough for estimating the demand due to existing connected load. In many cases where the load-distribution factors cannot be conveniently applied, on account of irregular arrangement of substations, feeders, etc., it will be more convenient and satisfactory to employ what is referred to herein as a total-demand factor. This is a combination of demand and diversity factors, in effect; and is simply an over-all demand-factor, used mainly in connection with certain classes of extensive industrial installations; such as steel and blast-furnace plants, etc. This factor, being the ratio of the net demand of the whole installation to the connected load thereof, includes the diversity element and will be explained further under a later heading.

TYPICAL VALUES OF DIVERSITY FACTORS

Typical average values of diversity factors shown below are based on data given in Messrs. Gear and Williams' book "Electric Central Station Distribution Systems;"† and are the results of tests and observations made in 1909, or thereabouts, on the lines of the Commonwealth Edison Co., of Chicago. Diversity factor studies of this character involve compiling the maximum demand records of a large number of consumers, together with making other numerous maximum demand tests, at different times, on feeders or substations or other points of supply; all of which requires much time and expense. Also, work of this character is, when started, especially liable to be set aside in favor of other these reasons (presumably) the studies referred to above, made in 1909, have never been repeated by anyone, so far as the writer can ascertain from considerable investigation.

Consequently, these diversity factors determined by Mr. Gear in 1909 are used extensively as a general basis upon which to assume suitable factors for other systems, and, due to the lack of more recent studies of diversity, they constitute about the only data available.

It should, of course, be recognized—in connection with any use made of these factors—that the conditions in Chicago, to which these figures originally applied, may differ from those obtaining elsewhere; where different rate schedules may apply, and different local conditions may obtain. It is, therefore, recommended that appropriate diversity factor values be assumed (for any given case) on the basis of the particular load-conditions obtaining, or expected; using the factor-values given below for general guidance in that connection.

Mr. Gear advises us that the factors for the smaller lighting consumers have probably increased materially during the past 10 yr.; which is in line with the increased use of portable heating appliances, etc. Accordingly the values for such consumers given herewith, which are based on the 1909 figures, should probably be raised a few per cent. The factors for power and large lighting consumers are believed to be reasonably reliable for present-day average conditions.

DIVERSITY FACTORS

(A) BETWEEN CONSUMERS (Several consumers being supplied from one service transformer):	
Residences, apartment buildings	.30
Commercial lighting:	
Small stores, restaurants, offices, lodge halls, etc. (as on outlying business streets)	.70
Office buildings (between individual consumers therein, including general power for elevators, etc.)	.67
Small power consumers: Light manufacturing, such as clothing manufacturers, woodworking establishments, etc., averaging around 5 hp. conn. load each	.70
(B) BETWEEN SERVICE TRANSFORMERS (On the same feeder):	
Residence lighting	.77
Residence lighting, together with about 25 per cent of small store lighting (power load 5 per cent or less)	.84
Combined residence and commercial lighting (in about equal amounts), together with about 25 per cent of miscellaneous power	.77
Scattered power consumers, with 40 to 50 per cent of lighting	.50 to .55
Department stores, large hotels, loft buildings, etc. (The higher figure would apply to load made up mainly of hotels, department stores and other large mercantile establishments, while the lower figure would apply chiefly to combinations of day power and evening lighting consumers.)	.75 to .92
(C) BETWEEN FEEDERS:	
If all feeders supply mercantile lighting, together with factory light and power (maximum demand at about 5 p.m. in winter)	.96

*Chief Engineer, Donora Steel Works, American Steel & Wire Co.

†Data used here by permission of D. Van Nostrand Co., publishers of "Elect. Central Station Distribution Systems."

Some feeders supplying mercantile and factory lighting and power, others supplying hotels, theatre and apartment building lighting and power (maximum demands at 5 p.m. and 7:30 p.m. in winter, respectively, for the two main groups named)..... .87
General power and large users..... .87

(D) BETWEEN SUB-STATIONS (Average)..... .91
This will apply when, say, 25 per cent of the power and lighting load has its maximum demand at about 7:30 p.m.
If part of the sub-stations serve manufacturing districts and others serve residential districts the diversity factor between these sub-stations may be lower than the above.
A diversity factor between main transmission lines (as at the central station, or other main distributing point) can probably be assumed at about the same value as the above, or, say, up to .96; although Mr. Gear's data does not give any value for this particular class of diversity factor for conditions where each main line supplies several sub-stations.

DIVERSITY FACTORS FOR COAL-MINING DISTRICT

Diversity-factor values given below were determined, in 1911-12, by tests made on a number of different bituminous coal-mining installations in the vicinity of Charleston, W. Va. These figures were furnished by H. W. Smith, now of the American Steel and Wire Co. As compared with other diversity factors previously given (of the same general order, but for different classes of load) they will further assist in forming a definite conception of the general range of values, that may obtain under different load and environment conditions.

DIVERSITY FACTORS BETWEEN BITUMINOUS COAL-MINING INSTALLATIONS

No. of plants in group	Sum of individ. max. demands	Max. coincident demand	Diversity factor
2	108 kw.	93 kw.	.86
6	480 kw.	394 kw.	.82
10	1663 kw.	1162 kw.	.70
12	1308 kw.	918 kw.	.70

TOTAL DIVERSITY FACTORS

A total diversity factor, as at any given point of supply in the system, can be determined for any one class of load, having a common diversity factor at the point of utilization. This total-diversity factor will be the continued product of the component diversity-factors, from the point of utilization up to the given point of supply.

For example: Required to determine the total diversity factor, as at the transmission line, for the commercial lighting load on a given system; the component diversity factors being as follows: Among consumers .70; among service transformers .77; among feeders .87; among substations .91. Total diversity factor for the commercial lighting load $= .70 \times .77 \times .87 \times .91 = .43$.

If the total diversity factor be multiplied by the consumers demand-factor, there is thus obtained another convenient factor; which can be designated as the per cent KW Capacity required per KW of Connected Load. Referring to the preceding example; if the demand factor for a certain consumer (or class of consumers) is 55%, the KW transmiss. line capacity required per KW connected load for this class of consumers would be $.43 \times .55 = .236$. Such factor is sometimes multiplied by 100 and referred to as "KW Capacity req'd per 100 kw Conn'd Load."

TOTAL-DEMAND FACTORS

We have already referred to the total-demand factor as a sort of over-all demand-factor; used in connection with certain classes of large industrial installations, where separate demand and diversity factors cannot be very conveniently applied. This situation obtains in regard to many extensive plants in which, for various reasons, there is not the uniformity in arrangement of the power-distribution system that is characteristic of public-service power-supply arrangements.

A plant of this character usually consists of a number of different departments, each of which frequently has a connected load comparable in extent with that of a fair to large-sized isolated factory installation; the load as a whole including numerous cranes, hoists, and other intermittent and highly-diversified load. These conditions apply particularly to such installations as steel and blast furnace plants, coke-works, ship-yards, ordnance plants, large mining developments, etc.

If the max. 15-min. demand of one of these large installations be determined at the main sub-station (or other point of supply to the entire plant); this demand, divided by the total rated connected load, equals what we will term the total-demand factor.

Such a factor has generally been referred to, heretofore, as the "KW max demand per KW connected load;" a somewhat inconvenient term. Since this factor, as applied to an extensive plant, embraces relatively more of the diversity element than does a demand factor (proper) some other name—implying this distinction—would seem to be in order. Since no short and convenient term has, so far, been in common use, the writer has nominated "total-demand factor" as a convenient designation for this per cent KW max demand per KW connected load; as applied to extensive plants or installations. The term seems to be appropriate, and, furthermore, it does not conflict with accepted terms for certain other load-distribution factors, such as "connected-load factor," "load factor," etc.

This total-demand factor is frequently used, under some other designation, in connection with estimating the net KW demand of industrial power systems; or portions thereof. It is determined in practically the same manner as a demand factor; i.e. by measuring the max demand (using, generally, a demand-meter or a graphic watt-meter) at the lowering transformer sub-station, central station, or other main supply point for the entire plant distribution system. This measured demand is then divided by the total rated connected load of motors, etc., within the plant; the result being the total-demand factor.

APPLICATION

In estimating the total demand of a plant the factor will, of course, be applied exactly the same as a demand factor; the total kw. net demand being the total rated connected load of the entire plant multiplied by the total-demand factor. Also, like the demand factor, values determined for one installation can be applied to other installations of similar character and load-conditions; for approximate estimation of the total net demand thereof. The main distinction between a demand factor and this total-demand factor is that the latter includes (in the factor) all of the diversity effects due to the more or less extensive and complex distribution system

that generally intervenes between the main substation, or other supply point for the plant, and the connected load. Thus the special convenience of the total-demand factor lies in that, by its use, the necessity of employing diversity factors is avoided; with the attendant difficulties that would be entailed in applying the latter to the irregular and complex distribution systems generally encountered in the classes of plants mentioned earlier in this connection.

As the extent of the installation, or plant, becomes less the total-demand factor therefor merges into the demand-factor proper; there is no definite dividing-line between them. In general, however, use of the total-demand factor presupposes a more or less extensive distribution system interposed between the connected load and the main substation, or other point, at which the plant is supplied by a main transmission line.

TOTAL DEMAND FACTORS FOR CERTAIN PLANTS

TOTAL DEMAND-FACTORS FOR CERTAIN PLANTS			
Class of Plant	Approximate Conn. Load	Total-Demand Factor	Class of load, departments included, etc.
Blast furnace plant and Ore Docks	6,300 Kw.	.35	4-blast furnace, sintering plant Theisen gas washers, centrif.' pumps (motor-driven), machine shop. Dock load includes 6 unloaders and 1 ore-bridge; with total conn. load 2000 Kw.
By-prod. Coke Works	3,400 Kw.	.27	180 ovens. Coal-handling equipment; crushers, breakers, conveyors, etc.; no hammer-mills. Large coal-storage yard bridge crane.
Steel Works	4,900 Kw.	.51	O.H. dept. (7 furnaces), Bessemer dept., steam-driven blooming, billet and rod mills.
Flat & cold-rolled strip mills & wire mill.	22,200 Kw.	.54	Elec. driven mills; consisting of hot-rolled strip mills, and continuous billet and rod mills. Also cold-rolled strip dept. and wire-drawing dept., all motor-driven. Total rated conn. load main mill drives = 12000 Kw.; largest being a 3000 hp. 6600 v. AC motor
Wire Works "A"	2,100 Kw.	.73	Wire-drawing, shafting, straightening and cutting, galvanizing and sulphate of iron departments. Also cold-rolled strip (so-called 'flat wire') dept.
Wire Works "B"	4,250 Kw.	.36	Coarse & fine wire-drawing depts., wire-rope mfg. dept., patenting and galvanizing dept. struct. steel fabric'g. shop, reel shop (wood-working), mach. shop
Bituminous Coal-Mining:			
Mine "A"	1,430 Kw.	.31	Average output 52,600-T/mo; or 2300-T/da. Max. 3100-T/da. Drift mine two entries; no gas, very little water. Haulage by elect. locomotives. At the time these observations were taken (1911-1912) this was one of the largest mines in the W.Va.coal fields
Mine "B"	360 Kw.	.13	Average output 6600-T/mo., or 250-T/da. General conditions about same as Mine "A".

Some Typical Values of Total-Demand Factors are given in the above tabulation. These are actual test figures, determined for a few fairly large steel (and associated) plants; and for two mining installations in the West Virginia bituminous coal field. The latter figures were obtained from tests made in 1911-12, but all the other figures are comparatively recent; and are from tests or operating records of year 1919 and later. This data is very limited in scope, and is intended mainly for illustrative purposes, the factors tabulated being only such as were available without making an extended canvass of various industrial power operating organizations. However, the values given can probably be used to a limited extent, and in some cases, as a sort of rough guide for assuming total-demand factors for proposed installations; where first-hand data of this sort are not available. It is probable that engineers associated with industrial power developments can, in most instances, work up similar and more suitable factors for themselves —from operating records of their own power-plants or substations; which procedure is necessary, with few exceptions, in order to secure the most dependable and accurate results. Accordingly the total-demand factors given below, together with the other matter in that connection that is included herein, is presented mainly by way of outlining a general method for use in connection with the classes of installations previously referred to; rather than an endeavor to offer factors that can be applied in all cases. It would be impracticable to do this, however extensive the tabulation of factors might be made; since wide variations in the total-demand factor can occur in different plants of the same general character, due to various local conditions and to differences in composition of the load.

Conditions Affecting Total-Demand Factor Values

Generally speaking, it is more or less unusual that any two plants of the same general class are encountered where the load-conditions do not differ to a considerable extent. This may be due in part to differences in the relative extent of certain departments; or to the omission or addition of one or more departments in one of the plants, as in case of the two wire works "A" and "B" of the preceding tabulation. Such differences of load-conditions are partly responsible for the fact that quite wide variations in the total-demand factor are likewise encountered frequently between plants of the same class. This is also due, in part, to such local conditions as have been previously referred to in connection with demand and diversity factors. In utilizing any given total-demand factor in connection with a proposed installation it is, therefore, especially important that the load conditions, under which that factor was determined, be known definitely and in detail. This information has been supplied, to such extent as is practicable, for the preceding tabulated factors; as given in the right-hand column of notes relative to each plant named.

These variations in the total-demand factor, between different plants of the same kind, are usually greater than is the case with demand factors (proper); which is, however, to be expected; remembering that the total-demand factor includes the effects of all the conditions associated with both demand and diversity. Such wide variation in this factor, example of which is had in the case of the two wire mills previously mentioned, is admittedly a disadvantage; as regards the general use of total-demand factors.

On the other hand, conditions are generally favorable for convenient determination of the total-demand factor at existing plants; it being only necessary to determine the max demand at the main substation, or other main supply-point for the plant. Graphic wattmeters are generally available at these points, at important works; and the max. demand can be determined fairly conveniently from the wattmeter charts for a month or so of normal full operation. This is done by selecting, on some one of the charts, the highest "sustained peak" extending over approximately a 15-min. interval; then figuring (by use of planimeter, or by averaging ordinates) the average power (kw.) during that interval. Use of a

demand-meter is, of course, preferable and more convenient; if same is available.

OTHER CONSIDERATIONS RE TOTAL-DEMAND FACTOR

If it is required to estimate the aggregate total kilowatt demand of an extensive plant, such as a steel works, shipyard, coke works, or the like; there are two methods available: (1) by total-demand factor, assumed on basis of a like factor that has been determined for some existing plant known to have practically the same character of load; or (2) by assuming demand-factors for the various load-groups, or departments, also assuming diversity factors as between the various co-ordinate parts of the system, as described more fully elsewhere in this article and in the preceding article of this series. The connected load must be known, in detail, in both instances. The conditions obtaining in case of any given project will, alone, determine which of these methods will be the more practicable; but it is probable that the total-demand factor method will be found more convenient, as a rule, in connection with the character of plants referred to above. This is assuming that a factor is available that has been determined for some similar existing plant. Probably both methods can be applied to many cases; one being used as a check on the other.

LOAD-DISTRIBUTION FACTORS—SUMMARY

We have seen that certain load-distribution factors; namely the demand factor and the diversity factor, can be utilized to determine the net total kilowatt demand of extensive distribution systems, of which the connected load is known. Total-diversity factors, which are combinations of demand and diversity factors, are of use in determining the additional capacity required at any point to supply additions to the connected load of an existing system. Also a sort of over-all demand factor, referred to herein as the "total-demand factor," can often be conveniently utilized for determining the total net max demand of certain large industrial plants; such as steel and blast-furnace plants, coke works, etc. The distribution systems within plants of this character are usually more or less irregular in arrangement, and on this account it is difficult to apply demand and diversity factors satisfactorily.

Maximum demand (of any distribution system, or part of a system), being the greatest average load during any relatively short interval, such as 15 min., or 30 min.; can be determined by a max demand meter, or from a graphic wattmeter chart. The ratio of this quantity to the connected load, which is the demand factor, may be determined on certain installations and afterwards applied to other like installations; for determining the max demand of the latter from the known connected load. The net max coincident demand of a number of services, feeders, or other co-ordinate parts of a system, can then be obtained by multiplying the sum of the individual max demands by a suitable diversity factor. Tabulations of demand and diversity factors have been given, for various classes of load, by use of which the aggregate net kw. demand of any given system can be estimated approximately. On certain classes of extensive installations, where it is inconvenient to apply these factors, more satisfactory results can probably be attained by use of total-demand factors; which have previously been referred to.

These various matters have been developed in some detail in preceding portions of this article; the immediate object having been to provide methods whereby the load at the receiving end of a transmission line can be estimated. Since some of the more important main power lines, supplying extensive distribution systems, come within the scope of these articles, it has been necessary to develop procedure appropriate for use in connection with major power projects. The same principles, however, will apply, and will be found useful, for estimating the power-demand of smaller installations; such as medium sized or large shops, factories, and other isolated plants, or departments thereof. The methods presented will also be appropriate for such problems as determining the additional capacity of generators, transformers, etc., required for supplying large blocks of load to be added to any given system. Such problems, although not strictly within the scope of these articles, frequently have to be handled in connection with the design of transmission lines.

Wild Animals Cause Service Interruptions

DURING 1922, fully 5 per cent of the severe disturbances to the transmission system of the Pacific Gas & Electric Co. were caused by wild animals and birds. Despite the fact that all high voltage lines are constructed with ample space between pairs of wires, animals with long tails and birds with large wing spread frequently touch or closely approach two wires at once, thus causing a short circuit and upsetting the electrical system. Needless to say, the penalty of such error in judgment is certain death to the too venturesome wild animal or bird.

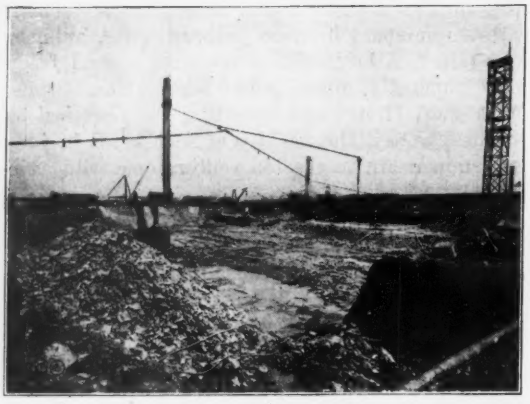
Some interesting incidents are given in a report by B. N. Merritt. Two hawks in the northern part of the state were seen to alight on adjacent insulators. They began to bill and coo, leaning toward each other until their beaks touched, thereby forming a circuit, killing the hawks and causing a short-circuit.

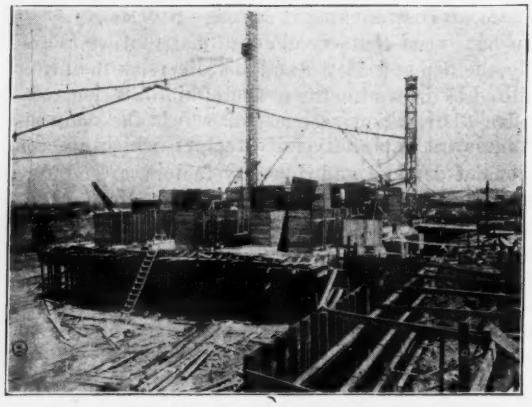
Birds are the chief offenders in so far as transmission lines are concerned; but wild animals, big and little, sometimes interfere with operation of another and no less important branch—the distributing stations and underground cables. Rats, mice, squirrels and cats add their quota of disturbing factors in the existence of operators and repair men. These animals accept readily the ready-made homes provided for them by the cable ducts and conduits. Owing to the network of high voltage wires and bus bars, there sometimes is trouble; but the animals that cause the trouble cease to be interested and the annoyance and grief are confined to the power companies and to the consumers.

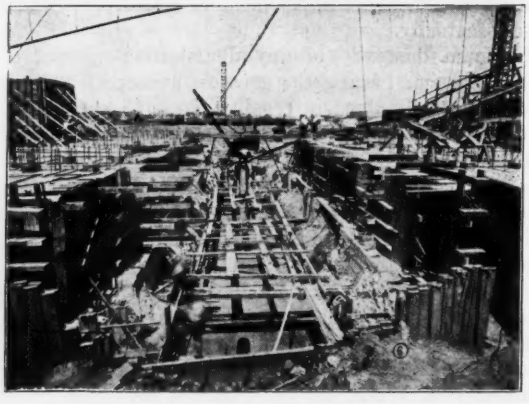
Correction Note

IN THE article on page 851 of the August 15 issue, describing the new McClave-Brooks mechanical stoker and the new hopper-feed hand stoker, the points of difference between the two designs are not quite clear. The view of the grate side of the hand feed stoker is shown as Fig. 1 in the article. The construction for the mechanical stoker is somewhat different as horizontal air spaces are used in the sectional-top grates while vertical spaces are used for the hand-stoker grates. The hopper-feed hand stoker is designed for use in plants where the small number or size of boilers makes mechanical stokers unnecessary.

Building the World's Largest Generating Station







We present herewith the second series of photographs showing progress in the construction of the Crawford Avenue Generating Station of the Commonwealth Edison Co., Chicago. Because of the magnitude of excavating operations, progress as shown in these views, compared to those shown in the August 1 issue, is not apparent. Work on the construction of the switchboard is advancing most rapidly and as may be seen in Fig. 5, concrete forms are already above the first floor.

Figures 1, 4 and 6 show various phases in the construction of the intake tunnel. Figure 6 was taken from the same point as Fig. 1, but was taken 13 days later. In Fig. 3, taken July 2, are shown excavating operations for the north tunnel shaft. Figure 2 shows the excavation for the turbine room and intake tunnel on June 26.

These photographs were taken by A. R. Gerlach, official photographer of the Commonwealth Edison Co., and are reproduced herewith by special permission.

Up-to-Date Practice in Electric Stations

NOTES FROM THE REPORT OF THE ELECTRICAL APPARATUS COMMITTEE OF THE N. E. L. A.

ONE of the most important problems in the operation of large electric generators is the matter of preventing or fighting fires in the windings of such machines. To assist in the formation of conclusions and recommendations on this subject, inquiries were sent to a number of representative companies located in all sections of the United States.

From a study of this information, the committee has submitted the following conclusions regarding the situation at this time.

(1) Past experience with generator fires has convinced those having that experience of the necessity of providing some definite permanently installed means of coping with generator fires, supplementing preventive means such as balanced differential relays, periodic insulation tests, etc.

(2) Only three of those who have installed on their machines permanent fire fighting facilities have had experiences in actual fire fighting with this equipment, these fires all being extinguished by the use of steam. Quantitative information on the subject is, therefore, meager.

(3) No failures have been reported on water protection equipment permanently installed in generators.

(4) Test data on experiments with inert gas (CO_2 in each case) have been published by two large operating companies, but neither one has had a fire in the generators to which fire-fighting equipment has been applied. Further tests are being made, using both carbon dioxide and nitrogen.

(5) On account of small quantitative information, it is not possible to claim actual superiority of one medium over another in extinguishing fires.

In connection with this general subject, the recommendations of the Underwriters' Bureau are of interest. These recommendations, in which the N. E. L. A. concurs, are as follows:

I. All turbo-generators of the horizontal air-cooled type, regardless of size, to be provided with openings in the outer casings, such openings to be covered by quickly removable plates through which quickly accessible hose streams can be injected into the windings.

II. Where space between the outer casings and windings is sufficient a suitable apparatus should be permanently installed for extinguishment of generator fires. This equipment may be of (1) internal water or steam spray type or (2) the type using steam application in air duct below generator; or (3) the type using a satisfactory inert gas. Any type using steam should be designed to avoid high tension steam impinging directly on the windings. All systems should be connected to a constant source of extinguishing medium arranged for quick application. Care should be taken to prevent water or steam leaking into the generator by installing proper valves and drip.

III. When conditions will permit, a well-installed balanced relay system should be provided which will electrically disconnect the generator from service.

Closed systems of generator ventilation, in which the air leaving the windings is recirculated and cooled after each passage, decrease the liability of internal fire because of the lessened ability to sustain combustion. A schematic section of such a system is shown in Fig. 1. The use of various inert gases to limit combustion still more, has been suggested.

AUTOMATIC VOLTAGE REGULATION

In general, the procedure in regard to voltage regulation is to operate the large plants with hand regulation and the smaller plants with automatic regulation.

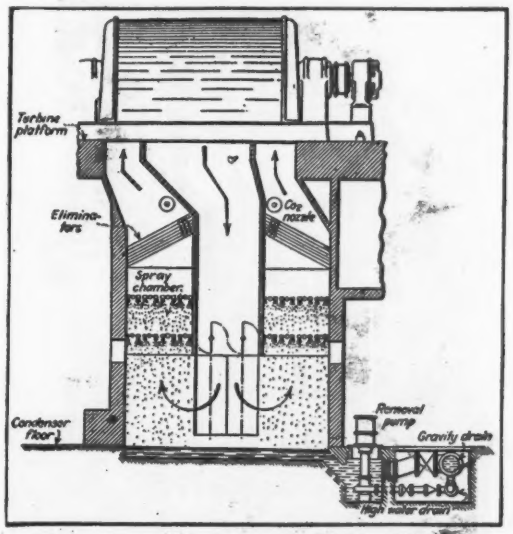


FIG. 1. SCHEMATIC SECTION OF CLOSED CIRCUIT GENERATOR VENTILATION

Of 29 operating companies reporting on this subject, 12 use automatic regulation and seven a combination of hand and automatic regulation.

Hand regulation appears to be satisfactory for large systems, supplying city loads of mixed power and light, with light predominating.

Where heavy power predominates on the system, as street railways, extremely large motors, such as used in the steel industry, and electric furnaces, automatic regulation becomes necessary, even on relatively large plants. Furthermore, where hydroelectric plants supply power over long transmission systems, it appears to be the prevailing practice to use automatic regulation.

All companies, reporting automatic voltage regulation, use regulators of the "Tirrill" type with the exception of one company which has installed a new type "face plate" regulator by which the rheostat in the main field circuit is operated automatically by motor. Exceedingly good results are reported with this type of regulation for which the following advantages are claimed.

(a) It permits use of storage battery or other constant potential source for emergency and eliminates the necessity for specially designed exciters.

(b) It is very easy to put into or take out of service enabling the operator to obtain hand control quickly and safely in emergency.

Control Systems

In some instances, too little attention has been given to the control system. In many good sized stations, all the control is supplied through an exceedingly small number of feeders, and sometimes the entire control circuit is handled by one feeder. As the control circuit often terminates at relatively exposed points, disturbances on the main system may cause burn-outs and similar troubles on the control system, thereby nullifying all automatic protection.

It is essential that a high degree of segregation should be maintained in the control system. Separate

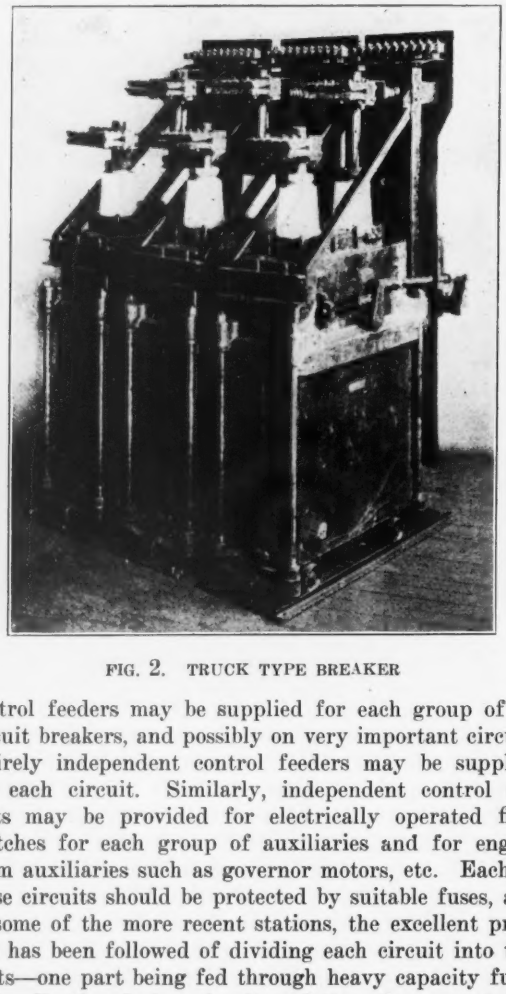


FIG. 2. TRUCK TYPE BREAKER

control feeders may be supplied for each group of oil circuit breakers, and possibly on very important circuits entirely independent control feeders may be supplied for each circuit. Similarly, independent control circuits may be provided for electrically operated field switches for each group of auxiliaries and for engine room auxiliaries such as governor motors, etc. Each of these circuits should be protected by suitable fuses, and in some of the more recent stations, the excellent practice has been followed of dividing each circuit into two parts—one part being fed through heavy capacity fuses to handle the closing circuit and the other part being fed through small fuses for the tripping and lighting circuit, each portion, of course, coming through a common switch. A further improvement is to provide a double throw control system and arrange each feeder switch so that it can be connected to either bus bar. This permits isolating any control circuit which is grounded until repairs can be made.

To secure the full advantage of the above system it is necessary to provide either two batteries and one charging set, or one battery with two charging sets.

Electrically Driven Auxiliaries

In practically all of the newer stations and those now under construction electric drive has been adopted for a very large proportion of the auxiliaries. The preference between the supply of energy from the main bus only, as compared to supply from a combination of house turbo-generators and house service transformers has shown a definite trend towards the latter, because of the advantage of independent sources of supply and adaptability to heat balance adjustment.

The only outstanding new feature in this connection is the adoption of a d.c. shaft driven auxiliary unit for supplying excitation and condenser auxiliaries or a.c. for supplying auxiliaries only. Of the first type, two 500-kw. units and of the second type five units of 1000 to 2500 kv.a. are being installed within the year.

Where combination auxiliary supply is provided, the independent services are connected to different bus bars and may be operated separately or in parallel. When operated in parallel, the tie connections have been arranged either—

(a) Direct, with relay protection only, or
(b) Through special heat balance motor-generator set.

Starting of Constant Speed A.C. Motors

Constant speed a.c. motors in generating stations are now being started by one of the following methods—

(a) Individual starting compensators or auto-transformers.
(b) Starting bus.
(c) Through individual reactors.
(d) Directly across the line.

Until recently general practice included the use of individual compensators or auto-transformers, but in several of the newer stations, such as Colfax, Calumet, Norristown, Devon, etc., a starting bus supplied from auto-transformers or power transformer taps has been provided. In the Delaware Station (Philadelphia) several 100-hp. motors have been installed which are started by inserting reactors in the line, which are short-circuited when the motor is up to running speed.

In the past two years, the possibility of starting squirrel-cage motors directly across the line in the larger stations, where there would be no objection from the standpoint of voltage fluctuation, has been discussed. In the Calumet Station (Chicago) several motors up to 150 hp. are regularly started in this manner.

In regard to the ability of the motors themselves to withstand the severe duty of starting under these conditions, manufacturers state that most standard motors will successfully meet this condition, but to guard against undue deterioration from frequent starting under this severe duty it is recommended that each individual case be specifically referred to them before purchase is made.

Application of Synchronous Motors to Auxiliaries

The general policy of most of the member companies is to induce customers to use synchronous apparatus wherever practicable to better power factor conditions. In generating stations, however, the use of the synchronous motor for auxiliary drive has been confined to such apparatus as motor generator sets, air compressors and in some few cases to centrifugal circulating pumps.

The question has lately arisen whether the synchronous motor should not be used more largely by central stations in their own plants in order to improve the power factor of the auxiliary load and to be in accordance with the general policy recommended to customers. While the economies obtainable are not quite comparable, the psychological effect would be helpful.

An example of the use of synchronous motor for circulating pump drive is the Harwood plant of the Pennsylvania Power & Light Company where three 500-hp., 2400-v. motors are in satisfactory operation.

Truck Type Breakers

Truck type breakers are coming more and more into use. In general, the truck breaker installed will require somewhat less space and costs somewhat less than the corresponding standard breaker with its structure and disconnecting switches. The great advantage of the truck breaker lies in the simple connections between switch and bus, the elimination of the disconnect switches and their hazards and clumsiness; small amount of labor required for installation; and ready interchangeability in case of trouble.

At present, breakers are available for voltages up to 15,000 with rupturing capacity at that voltage up to 20,000 amp. They are built for either hand or electric operation. Series transformers are usually mounted on the truck with the breakers. Typical designs of truck breakers are shown in Figs. 2 and 3.

Automatic A.C. Substations

Service rendered by automatic alternating current substations has been reliable and keen interest in this development is being shown. The reclosing circuit breaker which is the characteristic function performed in automatic alternating current substations, is reported as costing little where direct current solenoid switches are in use.

One company reports satisfactory operation with alternating current solenoid operated switches. Three companies are using motor operated circuit breakers, the motors being connected through suitable mechanical arrangements to standard hand breakers.

Temperature Indicators

With the adoption of forced ventilation of turbo-generators requiring a totally enclosed machine, the thermocouple or imbedded temperature coil became a necessary factor in determining the temperature rise of units under test conditions; following this use, the manufacturers began installing these devices for permanent record of operating temperatures. This record was, however, in most cases simply a matter of test data or of checking temperatures at periodic intervals to determine the condition of the unit as regards air flow, ventilating duct et cetera.

When manufacturers increased the temperature of turbo-generators, due to increases allowed by revised A. I. E. E. rules, many operators installed switchboard type temperature measuring instruments to permit reading the temperature at regular intervals and thereby keep in closer touch with actual machine performance. A demand was thus established for a curve drawing type of instrument which is now on the market and in use by a number of the larger operating companies.

These instruments are usually of the eight-point type, permitting the connection of six embedded coils, and inlet and outlet air. It is interesting to note the practice of operating companies in regard to the installation of these devices. Some companies are installing them on all generators, some on all new generators, and some only on generators which show a relatively high temperature under ordinary operating loads. A total of 36 have been installed to date, 24 for steam turbo-generators and 12 for water wheel units.

Various operating companies have reported trouble with temperature coils, both before and after they have been in service, these troubles, consisting of either grounds or open circuits, were probably due to weak mechanical construction or insulation defects which

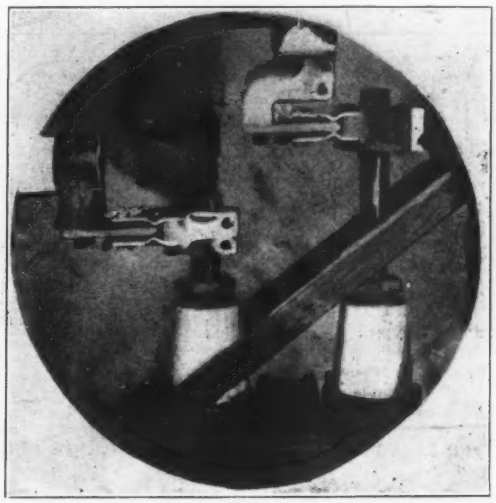


FIG. 3. MAIN CONTACTS FOR BREAKER SHOWN IN FIG. 2

became evident after the main windings in which these coils were embedded were forced into place. It is interesting to note, however, the wide variation in these troubles—on a system operating seven generators equipped with temperature coils, a total of 22 coils have become open circuited; on another system operating nine generators equipped with these coils but one coil has given trouble; other companies show records between these, whereas some companies report no trouble whatever; in addition to open circuit troubles some cases of ground have been reported, due to the breaking down of the fuses in the film cutouts. The manufacturers have recently improved these conditions by making stronger leads, providing better armor where the leads come out from the armature frame, making better connections from leads to temperature coils, and improving the protection of the detector proper so that it cannot be easily crushed between armature coils.

To determine the actual cost of coal at the stoker it is necessary to consider the price delivered at the station, cost of unloading, interest on the capital tied up in storage, cost of reclaiming and delivery to the bunkers, also the cost of distribution to the stoker hoppers and the cost of removing and disposing of the ash.

Power Developments in Great Britain

STATUS OF POWER PRODUCTION IN ENGLAND AS OUTLINED BY D. L. SELBY-BRIGGS BEFORE IRON AND STEEL INSTITUTE. BY C. H. S. TUPHOLME

SINCE THE main source of power in England is derived primarily from coal, it is evident that any investigation of the problems of power production must use coal as the datum line from which to start. It will be generally conceded that immense quantities of combustible fuel of low grade quality and waste gases remain unutilized at the present time, but with modern appliances and treatment could be converted in some form of power of great value.

While the scientific treatment of fuel has not until recently received much attention, there has developed, of late, a distinct tendency to investigate much more closely the economics of power production. Present

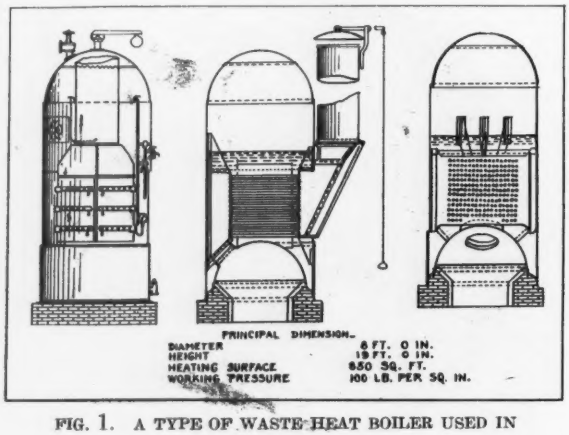


FIG. 1. A TYPE OF WASTE-HEAT BOILER USED IN BRITISH PRACTICE

methods in the generation and transmission of electric power have reached such a high standard, both as regards steam turbine practice and efficiency in electrical apparatus, that one cannot look to anything more than comparatively trifling economics in the engine room.

SAVINGS ARE TO BE SOUGHT IN THE BOILER HOUSES

It is towards the boiler houses and the efficient use of the various grades of fuel available for steam raising that one must turn when looking for savings, and where an immense field and ample scope for economy will be found.

This, however, is not the only source from which cheap power can be derived, and consideration will be given to the utilization of waste assets, in the form of blast-furnace gas, coke-oven gas, and gas from reheating and regenerative furnaces as applied to the raising of steam for power production purposes.

There is one very important point in connection with steam raising in industrial plants which should be emphasized, and that is the need for skilled supervision and control in the boiler house.

COAL CONSUMPTION

In a detailed investigation of 24 collieries in various parts of the country, instituted by the Board of Trade Coal Mines Department in 1918, it was found that the consumption of coal varied from 4.5 per cent to 16.5 per cent of the total production, showing that a wide variation exists in the economy obtained by various plants. It is well known that, while in certain districts, notably South Wales, special attention is being paid to the question of coal economy, there are still a large number of cases among the three thousand odd collieries of the country where little or no attention has hitherto been given to the question.

During the period of coal control, when the shortage of all classes of coal, due to war conditions, made it imperative to tap every available source, some most interesting researches were conducted by the Coal Mines Department. Among these was the possibility of utilizing "pit heaps," many of which had been standing for as long as 40 or 50 yr., and in a paper read by David Wilson, before the Association of Mining Electrical Engineers and Colliery Managers at Glasgow in 1918, a comprehensive analysis of these fuels was given.

It was calculated that at that time there were about 3,000,000 T. of so-called refuse coal lying at the pit heads, and estimated to be of an average calorific value of 5000 B.t.u.

Naturally, a great deal of this fuel was particularly high in ash, some of it containing even 50 and 60 per cent. Subsequent events, however, proved that a large proportion of this fuel could be used for steam raising purposes.

In the report issued by the Electricity Commission, in January of this year, the following interesting statistics appear, taken from public supply stations, consuming coal or coke:

No. of stations	403
Total units generated	4,965,514,403
Total coal and coke consumed, tons	7,356,757
Average coal consumption, lb. per unit generated	3.32
Lowest coal consumption at any station, lb. per unit generated	1.70
Highest thermal efficiency for any station (approximate), per cent	17.75

In connection with the use of coal for power production it is interesting to note the development of the Froth Flotation Processes for cleaning fine coals. The salient features of these processes are that coal or coal-bearing waste crushed to pass a screen of about 0.1 in. linear aperture is treated in the form of pulp consisting of approximately four parts of water to one part of coal.

Several units having capacities of 40 T. hourly are now in course of erection, and for a plant of this size the average cost of cleaning the coal, inclusive of power and labor, but exclusive of interest and depreciation, amounts to 4d per ton treated. The potentialities of these processes are therefore of importance; they open up the possibility of bringing to the surface and converting to industrial use the fine and low-grade coals of which considerable quantities are now left underground, while the grade of the coal treated is raised and its efficiency enhanced.

These processes constitute an advance in the conservation and utilization of fuels, and are worthy of the attention of those who are concerned with the production of power.

Water-Tube Boilers

Water-tube boilers have been installed capable of evaporating 130,000 lb. per hr. normally, and this duty has been increased on overload.

Pressures during the last few years have increased considerably; 250 lb. pressure is quite common, and several boilers are working at 350 lb. pressure. One large modern boiler house is being operated at a daily working pressure of 475 lb. per sq. in., and in one case which has created considerable comment, a pressure of 3200 lb. is contemplated.

Integral superheaters can now be fitted to boilers to give a final steam temperature of 650 to 750 deg. F., and this maximum is not likely to be exceeded, as it is approaching the limiting temperature of the steel tubes.

Stokers employed are mechanical, the chief makes being the chain grate stoker, with both natural and forced draft, the underfeed stoker, the sprinkler and coking stokers, and the multiple retort stoker.

Production of Power From Waste Gases

In general, the blast-furnace gases available in England are uncleaned, and when using such gas for firing boilers (more especially of the water-tube type), an external chamber is provided which, although it does not give such a good intermixture of air and gas as a Bunsen type burner, has the advantage of not becoming clogged up with dust.

With the advent in iron and steel works of gas-cleaning apparatus, the tendency is now to fit boilers with Bunsen or multiple-type burners, and whereas with the combustion chamber the efficiency under normal working conditions is probably not more than 63 to 65 per cent, for boiler and economizer, with clean gas and burners the efficiency can be raised, and 73 to 75 per cent obtained, which would mean that approximately for each pound of actual steam evaporated there would be required 16 cu. ft. of gas at 100 B.t.u. per cu. ft. The following are particulars of a test using blast-furnace gas in conjunction with a Harrison furnace:

Heating surface of boiler, sq. ft.	3082
Grate area, sq. ft.	43
Temperature of waste gases entering furnace, deg. F.	1892
Working pressure, lb. per sq. in.	130
Draft at boiler damper, in.	6.4
Water evaporated per hour from and at 212 deg. F., lb.	12,495

There is a considerable field for the utilization of surplus heat from coke-ovens and from the ordinary by-product coke-oven plant. It can be taken as a general average that 80 per cent of the gas will be available in the form of waste heat, at a temperature of 1800 to 2000 deg. F., and 20 per cent in the form of surplus live gas having a calorific value of 450 to 500 B.t.u.

Evaporation obtainable from the combination of waste heat and surplus live gas is approximately 1¼ T. of water, from and at 212 deg. F. per ton of coal carbonized. This surplus gas is generally burned in connection with Bunsen type burners, and efficiencies for boiler combined with economizer have been obtained as high as 80 per cent. Under normal working conditions, an efficiency of 70 per cent can be relied upon for boiler alone.

The following is a good example of figures obtained on test:

Total gas supplied per hour, cu. ft.	208,875
Calorific value (lower), B.t.u.	428
Evaporation (actual), lb.	58,060
Working pressure, lb.	196
Feed temperature, deg. F.	86
Superheat, deg. F.	158.60
Cubic feet of gas per lb. of water evaporated	3.58
Boiler efficiency, per cent	74.2
Efficiency of boiler combined with economizer, per cent	80.2

FIG. 2. COCHRANE WASTE HEAT BOILER WITH 500 SQ. FT. HEATING SURFACE, INSTALLED TO USE WASTE HEAT FROM A PLATE HEATING FURNACE

Where waste heat is available from coke-ovens, this could be utilized in the same way as that from a Siemens furnace, or a soaking-pit plant, excepting that the requisite draft could be furnished by means of an ordinary chimney. Particulars of a test on such an installation are given below:

Heating surface of boiler, sq. ft.	4170
Working pressure, lb.	157
Superheat, deg. F.	106
Temperature of gases entering the furnace, deg. F.	2228
Temperature of gases leaving boiler, deg. F.	500
Evaporation per hr. from and at 212 deg. F.	16,280
Evaporation per lb of coal carbonized from and at 212 deg. F.	1968

There is a great scope for the utilization of waste heat from reheating, puddling and other furnaces where the burned gases available are at temperatures of 1800 deg. F. to 2000 deg. F. The evaporation obtainable with a well-designed boiler is 5½ to 6 lb. from and at 212 deg.

F. per lb. of coal burned on the furnace, with gasses at 2000 deg. F.

It has been stated in the case of one firm, where a water-tube boiler was installed for utilizing the waste heat from two hoop mill furnaces consuming about 10 cwt. of coal per hr., that they have been able to save approximately 42 T. of coal per week.

In the case of regenerating furnaces, the gases available are in the neighborhood of 1000 deg. to 1150 deg. F., and although the introduction of a boiler in connection with reheating furnaces does not materially affect the draft conditions, a different case arises with regenerative furnaces, as the draft requirements are generally about 1 in. of water. This difficulty is, however, overcome by installing a boiler (or boiler and economizer) combined with induced draft fan, the fan giving the necessary suction to make up for the loss in draft through the boiler, and giving 1 in. of water at the boiler inlet.

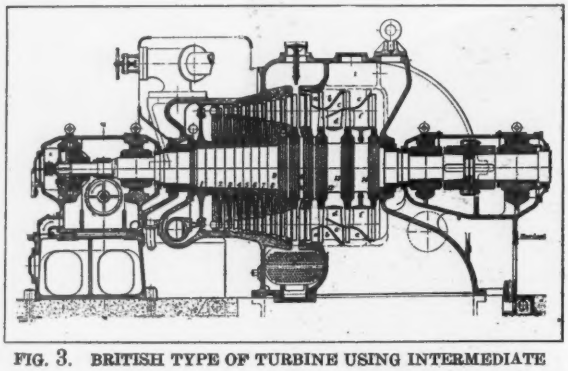


FIG. 3. BRITISH TYPE OF TURBINE USING INTERMEDIATE BLEED OFF FOR HEATING FEED WATER

There are many cases of installation where the fans are so arranged that a draft of 1½ to 2 in. of water can be given at the boiler inlet. By the installation of a fan the variations due to atmospheric conditions are eliminated, and it is almost certain that the steady conditions obtained when a waste-heat boiler and fan are provided improve the output of the furnace.

The evaporations in pounds of water from and at 212 deg. F. per lb. of coal burned on the producers obtainable from the waste heat of regenerative furnaces can be taken as follows:

Entering temperature	
1100 deg. F.	3.26
1000 deg. F.	2.76
900 deg. F.	2.27

As a general rule, the coal consumption on the producers is 5½ to 6 cwt. per ton of steel produced, so that, on a fair computation, it may be said that an average evaporation of about 2000 to 2200 lb. from and at 212 deg. F. can be obtained per ton of steel with gases entering at 1100 deg. F.

During the past 10 yr., remarkable improvements in steam turbine practice have been established by developing the use of higher steam pressures and higher superheat on the one hand, and by the adoption of higher turbine speeds on the other. The first of these two developments represents a direct improvement in efficiency of the thermal cycle of the steam, whereas the trend towards high-speed turbines offers advantages in various directions, distinct features being improved steam economy and reduction in the size of the machine for a given output, resulting in reduced first cost and in saving of floor space. The general trend towards highest possible turbine speed must be viewed separately, as this particular development has been possible not only because of improved methods of design and the production of high-class steels for the running parts of the turbine, but also to the great developments which have taken place in mechanical speed reduction gears.

Mixed Pressure Turbines

Mention must be made of the mixed pressure turbine, which has played a prominent part in the past. This type of turbine has rendered excellent services in connection with steam-driven winders and rolling-mills, utilizing from these engines the exhaust steam, which when exhausted to atmosphere would have constituted an appalling waste. The growing centralization of power production in collieries and steel works in parallel with the electrification of the entire plant tends to lessen the field of application of the mixed pressure turbine.

Reducing Turbines

A further type of turbine which in recent years has moved to the foreground is the reducing or bleeder turbine. This class is arranged automatically to bleed steam at a certain pressure for process work, mainly in paper mills, oil factories, distilleries, etc., or for heating purposes. The turbine utilizes the pressure energy of the steam between the boiler and pass-out pressure, which would be entirely lost if the steam for process work were tapped directly from the boilers through a reducing valve. When large quantities of low-pressure steam are required, as, for instance, in paper-mills, the saving in coal consumption with a pass-out turbine is considerable.

Actual test results of impulse turbines of the high pressure, mixed pressure and reducing type are given in the accompanying table.

Turbo-Compressors

The extensive application of compressed air in pneumatic tools for mining operations, for coal cutting, for riveting in shipyards, etc., has prepared the field for the advent of the turbo-compressor. One of the largest compressors bult in England has a normal capacity of 30,000 cu. ft. of air per minute, compressing this quantity against 100 lb. per sq. in. (G). The table I (F) gives results of a test upon a compressor of 20,000 cu. ft. capacity, 100 lb. per sq. in., delivery pressure. The air pressure usually required for the above mentioned purpose varies between 60 to 120 lb. per sq. in., according to the type of pneumatic tools used, and to the length of the distributing pipe lines. It is difficult to fix a limit for the maximum quantity that can be conveniently dealt with by a turbo-compressor. On the Continent, compressors have recently been built for 40,000 cu. ft. air volume.

Turbo-Blowers

Turbo-blowers and turbo-compressors are in principle one and the same thing, the name turbo-blower relating to machines working against moderate air pres-

sures, say, up to 40 lb. per sq. in. From the engineering point of view there is hardly an upper limit, within reason, for air quantities that can be handled by turbo-type blowers, the limit being drawn by economic considerations. A common size is the 35,000-cu. ft. blower. Anything above will rapidly increase the first cost without appreciably improving the running economy. The superiority of the turbo-blower and compressor over the reciprocator is similar to the position the steam-turbine occupies in relation to the steam-engine; reliability in operation, low cost of upkeep, and small floor space required are the prominent features of the turbo-blowers.

In the accompanying table, as item G, is given a test result of a typical blast-furnace blower.

Condensers

With reciprocating engines little or nothing can be gained in steam economy by the installation of condensers to give more than 26 in. Hg. vacuum mith Bar. at 30 in., but this does not apply to steam turbines, with which the highest obtainable vacuum can be fully utilized.

The requirement of the maintenance of a high vacuum, with turbines, has been met by the designers and makers of condensers and of auxiliaries for these, and recent improvements in the designs and efficiencies of centrifugal water-circulating pumps have been of great assistance in the economical operation of high vacua condensers.

The available types of condensers may be classified under three main heads, viz.:

(1) Surface condensers.

(2) Jet condensers with water extraction pumps and separate air pumps or other air extraction appliances.

(3) Ejector condensers with water-circulating pumps and no separate air pumps.

With surface condensers the condensed steam can be used for the boilers, and this has often led to their adoption where suitable water for boiler feeding was not available. Surface condensers are high in first cost, and their adoption may materially increase the cost of power station buildings. The use of condensers of this type, when clean condensing water cannot be obtained, necessitates troublesome and costly cleaning of tubes and periodical renewal of these. The modern method of dealing with boiler feed water by heat and soda ash has extended the application of condensers to the jet, or ejector types, with the advantages of reduced capital outlay, lower maintenance charges and continuity of service.

Water Cooling Plants

Only in a few cases will these be found where industrial sites are in proximity to a natural and adequate supply of water for condensing. This is not a serious disability as, with a loss by evaporation of about 80 per cent of the boiler feed, the condensing water can be re-used after cooling in towers or by spraying over ponds.

For high vacuum plants with artificial cooling the ratio of condensing water to the steam condensed should not be less than 60 : 1, this giving a maximum requirement of temperature reduction of 10 deg. F. for the cooling installations. The area required for cooling towers is 0.8 to 1 sq. ft., and for spray cooling plants 4 to 5 sq. ft. per kw. of plant installed. Where space is available, spray cooling should be adopted in preference to tower cooling, as the first cost is lower and better cooling is obtained with sprays. The maintenance charges for spray cooling plants are negligible, whereas with cooling towers the cover for maintenance and depreciation may be a heavy charge.

Space does not permit of more than cursory treatment of condensing and cooling problems, but that requirements can be satisfactorily met is shown by the following results obtained with an installation of ejector condensers with spray cooling plants, say for 3000 kw. turbo-alternators, installed at a colliery power station. With these plants 28-in. Hg. vacuum is obtained with Bar 30 in. with the turbo-alternators giving full output. The plants are simple, as for each turbine unit it is only necessary to operate two centrifugal pumps driven by one motor. The efficiency is high, as the current

RESULTS OF FRAZIER-CHALMERS RATEAU-TYPE TURBINE UNDER ACTUAL WORKING CONDITIONS

Ref.	Type of Turbine	Size in KW.	Speed in R.P.M.	Steam pressure Lb.Sq.In.	Superheat in °F.	Vac. at 30" Bar " Hg	Test Load in KW.	Steam consumption in Lb. Kw.-hr.
A	High pressure	3650	3000	140	150	150	3725	13.48
B	" "	5000	1800	175	125	27½	5000	14.08
C	" "	5600	1800	140	100	28½	5600	14.48
D	Mixed "	1000	3000	H.P. 140 L.P. 16 abs.	150 D.S.	29½ 29	940 979	14.60 29.35
E	Reducing	1930	3600/420	150 180	150 150	29 28	1875 96	15.45 Cond. all steam 26.35 passing out 15,000 lb. per hr. at 10 lb. per sq. in.
F	Turbo compressor High pressure	20,000 cu. ft. of air per min. at 60 deg. F. 30" Bar against 100 lb. per sq. in.G. 2650		190	95	29½	lbs./hr 37,700	
G	Turbo-blower	3500 cu. ft. of air per min. at 60 deg. F. 30" Bar, against 20 lb. per sq. in. G 3100		160	150	27½	32,900	Non-cooled blower

consumption for the motors is less than 3 per cent of the full load outputs of the turbo-alternators.

In the same power station the pumps for similar condensing and cooling equipments are driven by a high-speed engine, and as the exhaust steam for this is used for heating boiler feed water the operating costs are very low, and there is the advantage that no deduction has to be made from the output available from the turbo-alternator, as is the case with the motor-driven units.

Example of a Typical Industrial Power Station

It may be of interest at this stage to give a description in detail of a typical industrial power station, and for the purpose of illustration an actual case of a colliery power station in this country has been taken.

This power station was erected for the purpose of supplying electric power to a group of collieries principally for under-ground power, such as pumping, hauling, coal cutting, and general purposes, and also for main shaft hoisting. The system of supply, which was settled as far back as 1907, was 3000 v., three-phase, 50 cycles. The rapid power development since 1907 was such that the laying down of a large central station became imperative for the requirements of the area. The station equipment comprises at present one 1500-kw. turbo-alternator and two 3000-kw. turbo-alternators. The condensing

plant is of the multi-jet type, and the whole of the water required for condenser purposes is recooled through spray nozzles. It is possible to maintain a vacuum of 28 in. under full load conditions in the large units with barometer at 30 in.

In the boiler plant are installed six large boilers of the water-tube type, each capable of evaporating 22,000 to 27,000 lb. of steam per hr. The steam pressure adopted is 200 lb. per sq. in., with superheat to a total temperature of 588 deg. F.

Condenser requirements are all joined together, and any of the three circulating pump equipments in the station will operate any of the condensers.

No. 1 condenser is operated by a steam-engine, the other two by motors. There is also a steam-driven exciter and a motor-driven exciter, the latter of full capacity for all the units in the station. The exhaust steam from the condenser and exciter engines, feed pumps and fan engines is used for heating up the feed water. The feed water is treated in a heater softener by the temperature and soda ash methods.

Stokers are Erith retort type, with seven retorts each, and are capable of burning approximately 434 lb. of low grade fuel per hour. The first four stokers are operated by electric motors, but the fifth and sixth are operated by steam, as it is considered desirable to have some of the boiler plant operated entirely by steam and independent of the electric station. It will be noted that each pair of boilers is fitted with one induced draft fan and short chimney. The coal is tipped direct from wagons into the coal-pit. Hydraulic wagon tippers are used, one being placed at each end, to enable wagons to be handled without being turned on a turn-table. The coal is elevated from the dross tip to the large bunker alongside the boiler-house. Each boiler is fitted with an independent elevator, and all elevators are separately driven.

It is interesting to note that saturated steam is used for the small engines, principally because of the greater value of saturated over superheated steam for feed water heating. The steam and feed pipes are arranged on the "ring" system with isolating valves at suitable points. The ashes are taken direct from a hopper situated underneath the grates. The boiler-house floor is raised 10 ft. 6 in. above ground level to admit of this. The ashes are tipped direct into hoppers and conveyed by rail up an incline frame into the overhead bunker for tipping into wagons.

Main switchboard control panels are placed on the power-house floor level, and the cubicles containing the high tension apparatus are placed on a floor above the condenser house. The complete arrangement is compact and easily worked.

The following figures taken from the station records are interesting with 13,000-kw. unit running:

Units generated per week	416,950
Load factor, per cent	82.6
Wage costs	0.084c.
Coal costs	0.356c.
Oil and stores	0.022c.
Total production cost	0.462c.

The fuel was charged at approximately $2.78 per ton, and it should be noted that with low grade fuel charged, as is possible in many cases, at $1.20 per ton at the colliery, the fuel cost would be reduced to 0.154c. per unit, and the cost of production would then become 6.26c. per kw.-hr.

Nature of Lubrication in Engineering Practice

Experiments Made in England Show Remarkable Effects of Adding Minute Quantities of Organic Acid to Mineral Oils for Lubricating Purposes

IN A LECTURE delivered to the International Air Congress in London, June 29, 1923, Dr. T. E. Stanton, Director of the National Physical Laboratory, England, and Chairman of the Lubrication Committee of the Department of Scientific and Industrial Research, made known the results of his painstaking researches in lubrication.

Dr. Stanton's lecture goes most thoroughly into the whole question of efficient lubrication. With regard to the question of using grooves in bearings, he reaches some interesting conclusions.

In using an ungrooved journal and an ungrooved bearing, with castor oil as the lubricant, it was found that the coefficient of friction was 15 per cent *higher* than with the grooved surfaces. Substituting a grooved journal for the plain one did not improve matters. In the case of Bayonne oil, the increase in friction due to using ungrooved surfaces was 22 per cent.

"It is clear, therefore," stated Dr. Stanton, "that a system of grooving is essential in order to obtain the minimum friction due to the materials of the surfaces and the lubricant employed."

Paticular stress was laid by Dr. Stanton in his lecture on the value of adding small quantities of organic acid to mineral lubricating oils. According to the hydrodynamical view, the nature of the lubricant is immaterial, its viscosity alone affecting the result. Yet to take some figures recorded by Dr. Stanton, figures which are amply borne out by practical experience, the addition of 1 per cent of organic acid to Bayonne oil, an amount insufficient to have any noticeable effect on the viscosity, reduced the co-efficient of friction in a bearing by no less than 17 per cent.

Reynolds Theory Not Generally Accepted

"During the last five years," said Dr. Stanton, "considerable modifications have taken place in the views held by engineers of the action between the lubricated surfaces of the machines in which they are interested. The Reynolds theory of lubrication is so well known that I need hardly point out that the logical consequences of its acceptance are that the value of oils as lubricants depends solely on their viscosity, and that the nature and composition of the rubbing surfaces have nothing to do with the efficiency of the bearing. Curiously enough, the acceptance by engineers of these consequences has not been at all general.

"Our experience during the last twenty years at the

National Physical Laboratory has revealed a considerable demand for wear tests on metals suitable for lubricated bearings and a general disinclination of clients to be convinced that when the lubrication was satisfactory, wear was impossible, and that one lubricant was as good as another so long as its viscosity was up to a given standard. The existence of this feeling has been well brought out by Dr. Lanchester, who has insisted that, from the days of the millwrights of last century, engineers of wide experience have been fully alive to the fact that animal and vegetable oils were superior as lubricants to mineral oils of the same viscosity in virtue of some characteristic for which there was as yet no definite test.

"Until comparatively recently, it has been common to meet these objections by the statement that the Reynolds theory is not concerned with the manner in which the film is formed, but only with the conditions which exist when it is formed, and that it may well happen that in starting up machines from rest when the bearing surfaces are in contact, certain special characteristics of lubricant and bearing surfaces may be essential not only to prevent excessive wear, but to insure conditions favorable to the formation of a separating film.

"Gradually, however, it has become more and more certain that there can exist between rubbing surfaces a condition of steady lubrication whose characteristics are totally different from that of the Reynolds type.

"In laying the foundation of the theory of this type of lubrication, it must be confessed that engineers have taken little part, and the modern conception of its action is, in the main, due to the advances which have been made in the domain of physical chemistry with regard to the molecular phenomena occurring at the surfaces of solids and the manner in which films of foreign matter are condensed on these surfaces by the process known as adsorption.

Effects of Adsorption

"It is now recognized that solid surfaces having an adsorbed layer of lubricant of only one molecule in thickness can slide over each other with comparatively small frictional resistance.

"Further it is known that adsorption is dependent upon the chemical constitution of the lubricant, and that the greater the work done in the process of adsorption, the less the frictional resistance of the surface to sliding.

"Acids, alcohols and esters are more strongly adsorbed by water than are paraffins, and it is found that the former are better lubricants than the latter.

"There are therefore two essential different kinds of lubrication:

"In the one the surfaces are separated by a film of lubricant many hundreds of molecules in thickness, so that the resistance of relative motion to the surfaces is due to the lubricant in mass and the effect of the reactions at the two interfaces of lubricant and solid surfaces is negligible.

"In the other the molecular reaction at the common boundary constitute the whole of the resistance, which is therefore a function of the nature of the surfaces and the chemical constitution of the lubricant.

"In the former case the frictional resistance is determined by the viscosity of the lubricant and by the relative speed, configuration and attitude of the rubbing surfaces.

"In the latter case, it has been found by Prof. W. B. Hardy (Cambridge, England), to whose researches on this kind of lubrication much of the existing knowledge of the subject is due, that the coefficient of friction under these conditions may be written $U = Uo - aM$ where M is the molecular weight of the lubricant and "a" is a constant depending on its chemical constitution, Uo being a function of the friction of the surfaces when chemically clean.

Investigation of Boundary Lubrication

"Mr. Hardy has also shown that in this kind of lubrication, which he has termed 'boundary lubrication,' the relation known as Amonton's Law, or the Law of Solid Friction, is strictly followed, i. e., the friction for a given normal pressure between the surfaces in independent of relative speed and area of contact. . . .

"The importance, however, of the investigation of the extent to which boundary lubrication obtains and the way in which its characteristics may be modified under engineering conditions will be obvious from considerations of the enormous saving in cost of lubrication which might follow increased knowledge in this respect, and several attempts have recently been made at the National Physical Laboratory to set up conditions under which boundary lubrication could be conveniently studied on an engineering scale. The first series of experiments of this kind were made on the well-known machine designed by Dr. Lanchester for testing the efficiency of worm gears. That the lubrication between the surfaces of the worm and worm wheel in these gears was essentially boundary lubrication appeared to be certain from the results of the efficiency tests, which indicated a marked superiority of the animal and vegetable oils over the mineral oils as regards the temperature at which the gear could be run without a serious increase in the friction.

"Conditions of the test, however, were not favorable to the detailed study of the action between the surfaces, and in 1922 an attempt was made to imitate the conditions of pressure and arc of contact of surface in these gears in a cylindrical journal and bearing in continuous relative movement. The result of these tests, however, showed clearly that although pressure of 3.5 T. per sq. in. between the surfaces, and ares of contact of 14 deg. were obtained, the lubrication was undoubtedly that of the Reynolds type, since it was possible to measure the pressure of the oil film and its distribution by means of a Bourdon gage connected to a hole in the bearing. In this test the least thickness of the oil film was found to be .000046 in., which corresponds to a film of, roughly, 5000 molecules thick.

"It appeared evident that the existence of boundary lubrication depended on factors other than those of pressure and area of contact.

"After some consideration, an attempt was made to imitate the required conditions. . . . These were effected by the use of a pair of cylindrical lubricated surfaces in the form of a rocking shaft and its bearing, the oscillatory motion being produced by the attachment

to the shaft of a heavy pendulum swinging under gravity. From observations on the rate of damping of this system, it was thought that the magnitude and characteristics of the frictional forces at the lubricated surfaces could be determined, provided that a steady supply of lubricant could be delivered to the sliding surfaces.

"Since the time of oscillation of the pendulum is independent of the amplitude of the swings and the friction, it follows that if the successive amplitudes of vibration of the pendulum be plotted on a time base, the criterion of the existence of boundary lubrication will be the possibility of drawing a straight line through the extremities of the successive ordinates representing the amplitudes.

General Conclusions

"Results of the pendulum experiments show that by means of this comparatively simple apparatus the characteristics of lubricants and bearing metals under conditions of boundary lubrication can be investigated rapidly and conveniently.

"The experiments also show, in a manner which does not seem to have been demonstrated before, that in general engineering practice the lubrication of all machine details in which the relative motion is of a reciprocating character may be taken as boundary lubrication, and that consequently in such cases the improvements in efficiency due to the addition of organic acids to the lubricants employed will be realized.

"On the other hand, whenever steady relative motion of the rubbing surfaces can be maintained it would appear to be possible by the use of a suitable lubricant and correctly proportioned surfaces to set up a condition of film lubrication of the Reynolds type with all the advantages which this system affords.

"Further, the vexed question of grooves in bearing which has given rise to so much controversy in the past may now, it is thought, be regarded as settled. It was found by Beauchamp Tower that the presence of an oil groove in the crown of a bearing effectively prevented the formation of an oil film. It has now been demonstrated that in reciprocating motion a liberal amount of grooving to give the oil access to all parts of the bearing surface is necessary for efficient boundary lubrication.

"To what extent the values of the coefficients of friction obtained are absolute values for the materials and lubricant employed cannot be stated without further investigation, but it is thought from the results obtained with the plain bearings and journals that the difference is small.

"Experiments on the effect of different materials for the rubbing surfaces are in progress."

Good cotton rope dressing may be made by mixing 40 parts of acid-free tallow with 20 parts pure castile soap, 10 parts paraffine, 10 parts bees wax and 20 parts graphite. The tallow, soap and waxes should be heated but not boiled. Stir in the graphite while the mixture is still hot. The dressing may be moulded in any form suitable for use.

What School?

By N. G. Near

Among young men who are just starting or thinking of starting a technical course, the idea seems to be prevalent that it is much to their advantage to attend a large institution equipped with the latest and probably largest machines.

This question has been debated from every possible standpoint, and for preliminary training the advantage is often conceded, even by graduates of larger schools, to rest with the small school, even though not as well equipped as the larger one.

No school, for example, pretends to turn out a finished engineer with the possible exception of those where the university co-operates with factories in the city in giving young men suitable courses, and that course requires 6 yr. of continuous work, during which time the student is not advanced to a higher position in the business world; he is simply better prepared to enter his chosen professional field. The graduate of a four-year course in a small college, however, can easily begin an engineering career immediately after completing his course and after 2 yr. of work in good, sound engineering, he will already be advanced or will be as well or perhaps better fitted for advancement than the graduate of the 6-yr. school. Of course, this will be a hard thing to prove; in fact, none would attempt to prove it because we know that all colleges point with pride at the record of their graduates. The very smallest college has proved that it can send engineering graduates into the world who, in a few years of solid application, are able to compete with the best of engineers.

In nearly every branch of engineering, the most salient facts are based on a few simple fundamental principles which can be more easily demonstrated to students by use of small and simple apparatus than by use of the larger, more complex units. Every machine, no matter how simple or complex, is composed of a number of parts in which the underlying principles of motion are usually simple, being based on laws laid down in the science of physics. The mastery of physics, especially the parts that deal with forces at rest and in motion, is very important for one who would be an engineer. Therefore, if one is thoroughly grounded in physics, one should have no difficulty in mastering details of machines; and when all details are mastered, the machine itself is mastered.

In recent years the science of invention, which is closely allied to engineering science, has lost its spectacular nature and is becoming a more or less steady process of evolution. No machine of any importance ever just simply happened by accident to do the work for which it is valued, although this is believed by many to be the case. A machine is seldom unsuccessful because some main points of construction are wrong. The principal features of a machine or anything else are usually the easiest to determine. It is a failure because some little detail was overlooked, or hastily considered, or allowed to be neglected, because of the irksome labor necessary to work it out properly. A knowledge of theory and good judgment in connection with it for application to detail are the two weapons an engineer must be equipped with on entering a professional engineering career.

Method of Reclaiming Rod Brasses and Valve Stems

RECENTLY we engaged in overhauling our engine and among many other jobs did some work on the connecting rod, brasses and the valve stems. The boxes were in good condition, but had become loose in the rod. These boxes were of solid brass and rather than replace them we expanded them as shown in the accompanying sketches.

We turned up a steel mandrel, the same size as the pin, and laid the half brass on it. We then inserted a piece of tin on each side as shown in Fig. 1. This caused the brass to stand open at A. An iron block was then placed on top of the brass and upon this a sharp blow was struck with a heavy hammer. In this manner,

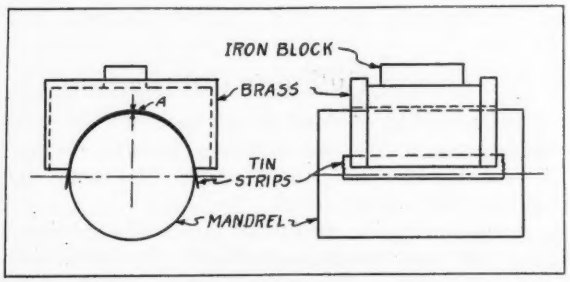


FIG. 1. STEEL MANDREL WAS TURNED TO SAME SIZE AS THE PIN

we were able to spread the brass until it formed a drive fit in the rod.

This method can only be used on a solid brass box. The babbit of a lined box would loosen under the hammer blows. Rather than to expand a solid brass box too much it would be better to braze on a strip of brass and file the box to a fit in the rod.

We also found the valve stems considerably worn in the stuffing-box, Fig. 2. This was caused by the hardening of fabric packing. The stems were otherwise in good condition, so it was decided to turn down that part which was worn. One stem was so badly worn that it was necessary to build up the worn section by welding and then turn it down to its original size. We then repacked the stems with a metallic packing.

TOM JONES.

Gasket Practice

IN REPLY to Joseph Schmitz's comment, on page 744 of the July 15 issue, to my letter, on page 390 of the April 1 issue, I should say that it would doubtless be expecting too much of a flexible metallic gasket to think that it can take the place of the pipe bend or expansion joint in long pipe lines even where only saturated steam is used. I do believe, though, after my 10 yr. of experience with flexible metallic gaskets, that by putting in a sufficient number of joints the gasket would take care of all expansion and contraction in a saturated steam line of considerable length—possibly any length. That is a point that has not been tested in actual practice and it doubtless never will be because it would be rather expen-

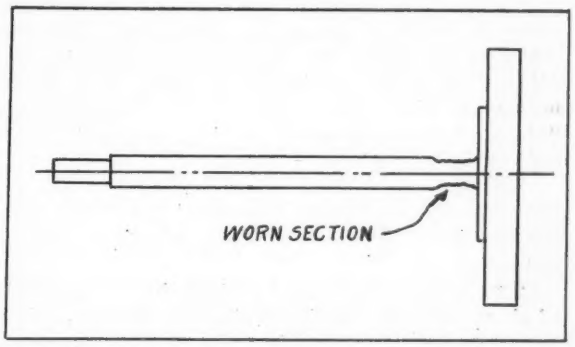


FIG. 2. VALVE STEMS WERE WORN DUE TO EXCESSIVE FRICTION

sive to put in so many joints. Besides, it would not be good engineering practice. I find that for short lines there is nothing better, and in long lines the gasket is a decidedly valuable adjunct to the pipe bend and to the standard expansion joint. It has been recently pointed out by a prominent national committee that important advantages are to be gained by making joints flexible. The results of the committee investigation which were published subsequent to my article in the April 1, Power Plant Engineering, verify my contention in that article.

It used to be true that a thin gasket was preferable to a thick one; however, in order that the gasket may be flexible as well as tight it is impossible to have it both thin and flexible, hence the construction which is shown in the accompanying sketch. It is made of a combination of steel and asbestos, the steel being a piece of strip metal bent into the form of a "U" at its center, as shown. This strip is then wound spirally, beginning on the inside and winding outward so that the "U's" dovetail one into the other. A layer of asbestos is wound solidly between every layer of steel. This forms an impervious, strong, flexible, steel-asbestos gasket with about 19 plies to every inch width of flange. It contains more asbestos than steel.

It is true that combination rubber and asbestos gaskets should be made thin; the thinner the better. I noticed in a recent article in Power Plant Engineering that where high pressures are used, gaskets are sometimes omitted altogether by grinding the joints. In other

words, the thickness of the gasket then becomes zero. Also, as stated by Mr. Schmitz, the thin gaskets must be tightened up tightly or they will leak. I will have to admit that I have not yet had any experience with some of the so-called modern high pressures ranging from 600 lb. per sq. in. upward, consequently I do not know how the flexible metallic gasket will behave under such pressures. I am certain about one thing, however, and that is, the gasket will not blow out.

Regarding the length of wrenches, I agree with Mr. Schmitz that wrenches are made in lengths that are not standard, but special wrenches are an exception rather than the rule. Sometimes very short wrenches cannot be avoided; sometimes very long wrenches are necessary in order to reach bolts in almost inaccessible places. Thus ratchet wrenches, for example, often have unusually long handles. It is easy to show, however, that for every diameter of bolt there is a proper length of wrench, provided the bolt has a standard number of threads per inch as most of them have. Where the number of threads varies the length of handle also should vary. Under no circumstances should the wrench be so long that it is liable to stretch the bolt beyond its elastic limit, or strip the threads with ordinary arm power. Under such conditions, when the wrench is too long, judgment must be used in tightening bolts.

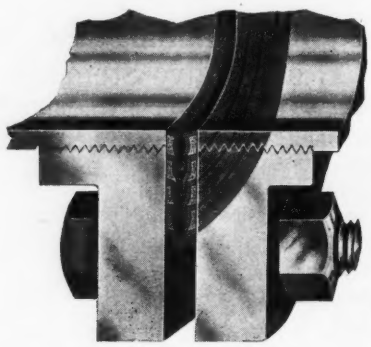
Not long ago, I came across some data on this subject in Mark's Mechanical Engineers' Handbook regarding the size of wrenches and bolts sometimes used. It states that:

"Tests made by Crane Co. show that a compression of about 12,000 lb. can be obtained by one man using a 16-in. wrench on ¾ to 1-in. bolts, a 36-in. wrench on 1⅛ to 1⅜-in. bolts, a 60-in. wrench on 1½ to 1¾-in. bolts, and a 72-in. wrench on 1⅞ and 2-in. bolts. Square nuts give from 20 to 25 per cent less compression than hexagon nuts with a given effort on the wrench. Rough-cut or uneven threads reduce compression 10 to 15 per cent. Lubrication of thread and bearing surfaces increases compression about 50 per cent over that obtained with dry threads and surfaces. It is not necessary to overstrain bolts specified in the American Standard if proper wrenches are used, and almost impossible to overstrain bolts larger than 1 in. in diameter. The following overall lengths of box wrenches are recommended (interpolate for intermediate sizes.)"

Size of Bolt, inches	Length of Wrench, inches
½	7¾
⅝	9⅞
¾	11½
⅞	13¼
1	15
1¼	19
1½	23
1¾	27
2	30½
2¼	34

I was glad to discover the foregoing quotation because it certainly indicates that there is a proper length of wrench given for ordinary flanges with ordinary gaskets; but even with standard wrenches, where flexible metallic gaskets are used, it is well to be careful. It is necessary to be more careful than where the old style thin sheet rubber or combination rubber and asbestos gaskets are used.

In reply to Mr. Schmitz's last paragraph, the gasket illustrated in the sketch shows the requirements very well, I believe. This gasket is used not only in pipe flanges but for boiler handholes and manholes where it is claimed by boiler manufacturers to give exceptionally good service. Being made of steel and asbestos, and, provided it is not stretched beyond the elastic limit, this gasket can generally be used over and over indefinitely without showing any signs of leaking. Labor is saved.



COMBINATION STEEL AND ASBESTOS FLEXIBLE GASKET

Joints are saved. Leaking is stopped. Expansion and contraction are not so liable to cause trouble.

Camden, N. J. HENRY BOHMER, JR.

Steam Cylinder Lubrication

ON PAGE 746 of the July 15 issue of Power Plant Engineering, C. J. Mason gave a formula for use in determining the quality of oil required for steam engine cylinder lubrication.

In order to bring out further information on this subject, more particularly as applied to the lubrication of compound engines, I have made the following computations, which, in this case, may be compared with actual practice. The engine in question is a cross compound having a high pressure cylinder 18 in. in diameter, low pressure cylinder 36 in. in diameter, a stroke of 30 in. and a speed of 150 r.p.m.; steam pressure 150 lb., vacuum 26 in. and moisture in the steam 2½ per cent by test. Applying the formula, namely, diameter × stroke × r.p.m. × 0.0066 (a constant) = 3.72 oz. oil for the high pressure and 7.425 oz. of oil per hour for the low pressure cylinder. The oil actually supplied to the two cylinders by measure was 1.3 oz. for the high and 1.54 oz. for the low pressure cylinder, and the lubrication was satisfactory.

Transposing this formula and solving to find the constant for each of the cylinders on the basis of the actual quantity of oil used, gives a constant of 0.0023 for the high and 0.001,37 for the low pressure cylinder. It is certain that the last constant (0.001,37) is too small, as the low pressure cylinder receives a good portion of the oil supplied to the high pressure cylinder. The oil used is a compound mineral oil forced into the steam pipe by a pump having a plunger adjustment to increase the size of the drop of oil, but not the number of drops in a given time, and also an adjustment to increase the speed of the pump to increase the number of drops of oil to the cylinder in a given time.

Moisture in the steam was determined by a Barrus calorimeter to be 2½ per cent. The feed water was at times acid and at others alkaline as fed to the boilers. Due to the moisture carried over, this had a direct bearing on the proper lubrication of the engine. It was the intention to maintain the water to the boilers in a neutral condition (neither acid nor alkaline), and if the steam had been dry or superheated a different oil would have been required. There are engines running which use little or no oil, and there are cases with no other lubrication than a grooved cylinder, the grooves seeming to hold some water which acts as a lubricant. The important point for consideration is to determine how small a quantity of oil it is possible to use for efficient and safe lubrication, with a margin of safety for varying steam conditions. If the condensate is used over and over again it is advisable to leave a minimum amount of oil in the boilers to avoid trouble due to blistered tubes or shell. It would seem that the formula and the constant given are safe but should undoubtedly be modified to suit the condition of the steam.

An oil that will answer for both superheated and dry saturated steam should be one that will atomize easily but not emulsify. The tallow or fat used for compounding should not readily be thrown down, saponify or become acid with heat. The engine cylinders and the condition of the condensed steam should show that the oil is effective. The oil used with superheated steam should not be burned up or carbonized by the dry high temperature. It should be tested to indicate the co-efficient of friction at the temperature of the steam in which it is used and under a bearing pressure of 100 lb. per sq. in. of bearing surface. Lists should also be made of its atomizing and non-emulsifying properties.

Compounded mineral cylinder oil that has given good results for either dry, saturated or superheated steam tested as follows: At a temperature of about 400 deg. F. the co-efficiency of friction was 0.05 with 100 lb. per sq. in. on the bearing surface. The gravity was 25.7, flash point 560 deg. F., fire test 625 deg. F. Viscosity 182 at 212 deg. F. and the cold test 47 to 50. No mineral or animal acid was shown by test under heat, and the viscosity tests on many samples of this oil from different lots varied from 175 to 210 at 212 deg. F. This oil was compounded with 6.6 per cent of acidless tallow.

The quality of iron in a cylinder will have some effect on lubrication, as evidenced by the operation of two engines purchased at different dates but carrying about the same load and using steam from the same boilers; one will often require more oil for quiet operation than will the other.

With a good filter in the feed line, there should be little or no trouble with oil in the boilers, and such a filter should reduce the quantity of oil in the condensate from 10 grains per gallon to ½ grain or less, depending on the condition of the water and the filter. The length of runs between cleanings should be reasonable if sufficient filtering area is provided and the water velocity kept low. A good separator backed up by an oil filter using terry cloth as a filtering medium will be found satisfactory.

Taking the engine in the example here given, the total oil if not carbonized or worn out would be (1.3 + 1.54) = 2.84 oz. per hr., or 4.26 lb. of oil every 24 hr. Since there are 7000 grains in one pound, an oil filter must remove in this time 29,820 grains of oil. If this oil is contained in 120,000 lb. or approximately 14,450 gal. of water, this gives an indication of the work a filter must do in a given time.

It would be interesting to hear from users of filters with terry cloth as a filtering medium as to the length of runs obtained between cleanings, the number of gallons of feed water filtered per 24 hr. and the quantity of oil removed from both filters and terry cloth.

Water Tube vs. Fire Tube Boilers

On page 746 of the July 15 number of Power Plant Engineering, W. C. F. asks whether he should install water or fire tube boilers in his plant. From the data given, I would understand that he is limited to a boiler room 16 by 35 ft.

Installation of a 550-hp. uniflow engine will require 350 boiler hp. for its operation at full load. This type of engine will doubtless call for a high steam pressure, in which event the water tube type of boiler would be best adapted.

One boiler rated as above might seriously handicap the plant for power and steam should it be necessary to take the boiler out of service. Two boilers would give protection against all steam and power being cut off. Two water tube boilers rated at 350 hp. each would assure continuous operation at full load. Two water tube boilers rated at 175 hp. each would give assurance that 50 per cent of the load would be carried except in an extreme emergency. Neither of the two water tube boiler combinations will fit into the space available, although it would seem that a possible re-arrangement in the pump could be made which would allow widening the boiler room.

If no more space can be made available, it would no doubt be advisable, for reasons given above, to install two 72-in. by 18-ft. horizontal tubular boilers rather than the single 350-hp. water tube boiler.

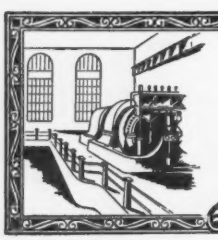
While the chimney is not any too high, it will do the work satisfactorily most of the time. Increasing the chimney height or installing mechanical draft would be effective if more draft should be required.

G. H. Kimball.

Supplementary Heating Coil in Hot Water Heater

In our plant it was found that, owing to an increase in production, water could not be heated fast enough in a 5000-gal. heater to supply the needs of the users, even with live steam at as high a pressure as was deemed safe to carry on the system. Another coil was built, duplicating the original one, and on a Sunday the old coil was disconnected, and tees inserted as shown at A, A in the accompanying sketch and the new coil installed, as shown. Struts were bolted to the original supporting plates, carrying plates to support the new coils. No trouble was ever experienced in maintaining a sufficient supply of hot water by the use of exhaust steam only.

Camden, Me. M. M. Brown.



PROBLEMS IN OPERATING POWER EQUIPMENT

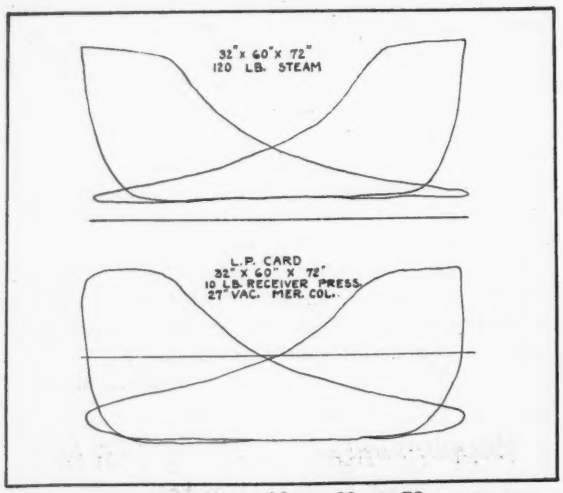
Substitute for Heating Boiler

I WOULD like to have the opinion of my fellow readers of Power Plant Engineering as to the practicability and economy of heating the water for a hot water heating system with exhaust steam. I have a building containing 13,000 sq. ft. of direct hot water radiation. At present, the water is heated in boilers located in the basement. It is desired, however, to dispense with the boilers and heat the water with steam from a low pressure steam heating system located about 500 ft. away.

Is this plan feasible and will it prove economical? Should the heating be by means of a closed or open heater or by a mixing valve? What storage capacity will be required in the basement? R. N. D.

Can This Engine Develop More Power Economically?

WE HAVE in our plant a 32 by 60 by 72-in. George H. Corliss cross compound engine which is about 40 yr. old. It runs at 57 r.p.m. under 120 lb. steam pressure and 26 to 28.5 in. vacuum. Can this engine be made to develop 1800 hp. on 130 lb. pressure, and do it economically? Indicator cards from this unit are shown in the accompanying diagram. S. E. C.



INDICATOR CARDS FROM A 32 BY 60 BY 72-IN. CORLISS

A. If this engine was designed for the load which it is now carrying, as shown by the indicator diagrams, it is likely that this is the most economical load. On an engine as old as this one is, it is probable that the economy is not high at that. Any increase in load will mean an increase in steam consumption per indicated horsepower-hour, the amount depending on the characteristics of the engine.

By integrating these cards it is found that the indicated horsepower of the high pressure cylinder is 655 hp. and that of the low is 670.

As indicated, the mean effective pressure in one end of the high pressure cylinder corresponding to the normal load of practically 330 hp. is 40 lb. With a receiver pressure of 10 lb. gage or, say, 25 lb. absolute, the mean forward pressure is 65 lb. and the ratio of the mean forward to the initial pressure is $65 \div 135 = 0.48$. With ideal expansion this would call for a cutoff at 17.5 per cent of the stroke. The actual card shows a cutoff of 25 per cent corresponding with this condition. With 130 lb. gage initial pressure and the same ratio of mean to initial pressure, the mean forward pressure would be $145 \times 0.48 = 69.5$ lb. or 44.5 lb. m.e.p. resulting in a power increase of $4.5 \times 40 = 11.25$ per cent, giving 368 hp. If the engine is to develop 1800 hp., each end of each cylinder will have to develop 450 hp. a further increase of 22.25 per cent. A proportionate increase in m.e.p., or a total of 54 lb., will be necessary. With the same receiver pressure the mean forward pressure will have to be 79 lb. The ratio of mean forward to initial will then be $79 \div 145 = 0.545$ which with ideal expansion would call for a cutoff at 21.25 per cent of the stroke. With the expansion as found on the actual engine, the cutoff will have to be $25 \div 17.5 \times 21.25 = 32$ per cent.

Should Well Enough Be Left Alone?

"SHOULD well enough be left alone?" as questioned by your correspondent, G. L. B., on page 846, Aug. 15 issue, depends upon how much extra cost or extra effort would be required to obtain something better than what is termed "well enough." Sometimes it does not pay to do a thing the best it can be done, hence the excuse for the expression we so often hear, "good enough."

In the case cited by G. L. B., I think a little further improvement may be made with a little extra effort, and no extra money cost. The diagrams submitted represent a pretty good valve-setting and steam distribution, particularly those of the high-pressure cylinder; in fact, the high-pressure diagrams show an ideal condition of affairs in that cylinder.

With regard to the low-pressure diagrams, the rounding corners at steam admission, above the atmospheric line, which shows that some power is lost at the beginning of the piston stroke, due to a late lead, or at least at too small port opening after the piston has begun to move. This can be remedied by increasing the lead, which in turn means increasing the angle of advance of the eccentric. Doing this will also increase the compression in that cylinder, but it may be done to some advantage, as shown by the very small amount of compression which exists at present.

There is another point which I think worthy of comment and suggestion, and that is the receiver pressure at present. This is stated as 10 lb., with an initial pressure in the high pressure cylinder of 135 lb. or thereabouts.

When the cylinder ratio is taken into account, I am of the opinion that a higher receiver pressure may be advantageously carried. As no scale of diagrams has been given, nor any scale of reduction from the original diagrams, I have made no attempt to calculate the powers developed in each cylinder, but I should judge that the greater power is being developed in the high-pressure cylinder. In a tandem-cylinder engine, where the low-pressure cylinder is the nearer to the crank, it is better to have the greater power developed by the low-pressure cylinder, if there is to be any difference at all. In no case should the high-pressure cylinder be permitted to develop the greater power, unless, as in an extreme design, where it is nearest the crank.

So, by increasing the receiver pressure, the initial pressure in the low-pressure cylinder will be higher, the cutoff will be earlier, and the terminal pressure will be lower, which, when within reason, is what is required for best all-'round results.

Just how much the receiver pressure should be increased in the case we are considering can only be found by actual trial. The practical way to go at this is: shorten the low-pressure cutoff until the receiver gage shows 15 lb., then take indicator diagram from the low-pressure cylinder, and note the amount of reduction in the terminal pressure on both head and crank end diagrams. I would suggest that it be reduced to 4 or 5 lb. absolute, which is not reducing it to an absurdity. At present the terminal pressure is about 7 lb. absolute, as near as I can judge.

Also, I should judge from the data given, and upon an analysis of the diagrams submitted, that probably the receiver pressure should be increased to 20 lb. gage for the desired results. By making the changes suggested in the foregoing, a small degree of economy will be realized, which only a long period of time will be worth striving for.

In conclusion, it has been said by somebody in the past, with a tandem cylinder compound steam engine to operate the engine at that receiver pressure, which, for any given load on the engine, will cause the governor balls to float in the highest plane. A little thought spent on this will make the matter clear.

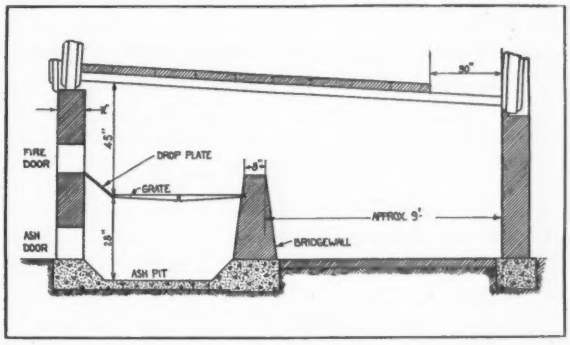
CHARLES J. MASON.

Change in Furnace Setting

IN THE Aug. 1 issue of Power Plant Engineering, on page 796, F. G. F. asks for opinions on what would be advisable to eliminate smoke in his boiler when burning wood.

In the past and at the present time, I have made a number of installations with an equipment which will reduce smoke considerable in hand-fired units. This equipment consists of a plate placed just ahead of the dead plate in the furnace. The plate has slots about ⅜ to ½ in. wide extending almost the width of the plate. It also lowers the grates the desired amount, that is, if it is necessary to lower the grates 6 in. a 6-in. drop plate is used. When firing a furnace with these plates the fuel is kept forward on the plate as much as possible, leaving the slots clear for the admittance of secondary air. In placing these plates I never use the common straight or herringbone type of grate, but a grate which has a large area of opening for the free flow of air to the fuel bed.

Previous to installing the plate and grates it was hard to keep up steam, burning shavings and coal, with a high per cent of waste, the former equipment being the common straight grate. The present grate burns a lower grade of coal with shavings with little smoke and a reduction of about 10 per cent in the fuel consumption with an evaporation that gives sufficient steam to carry on the production.



INSTALLATION OF DEAD PLATE AT FRONT OF FURNACE, PLOTTED TO ADMIT SECONDARY AIR FOR COMBUSTION, REDUCES SMOKE FORMATION

The attached sketch will give an idea of how this equipment is installed.

North Tonawanda, N. Y. CHAS. J. MILLER.

Will Two Feed Water Systems Be Necessary?

IN REPLY to the question by A. C. on page 796 of the Aug. 1 issue of Power Plant Engineering as to whether or not he would require two feed water systems to supply boilers operating at different pressures, it will not be necessary to install a separate feed pump for the higher pressure boiler. The 6-in. header can carry the required pressure and all boilers can be fed from this line. I assume that check valves are installed on the branches leading from the header to each boiler; if not, they should be.

I am using practically the same sort of installation in my plant, with the exception that I do not use feed water regulators, but I see no reason why they cannot be used if so desired.

In regard to the boilers of the lower pressure robbing the higher pressure boiler of the feed water, if it were necessary to run with all feed valves wide open at all times some trouble would likely be experienced in supplying water to the boiler carrying the higher pressure. The feed water supply should be adequate in order that the feed valves may be partly closed when the boilers are in operation so as to allow for adjustment to suit the demand for water.

Lowell, Mass. E. C. W.

POWER PLANT ENGINEERING

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Application of Mechanical Coal Handling Methods

Coal, when used as a fuel for the generation of power, must be charged with the cost of handling from the time it is received at the plant until it is consumed in the furnaces. These charges will result from unloading the coal, transfer to bunkers or to storage, reclaiming from storage and distribution to the stokers.

Methods which may be employed for these operations vary greatly in first cost, operation costs and the cost of maintenance. The true engineering involved then is in the selection and arrangement of equipment such that the costs as stated above will be in proportion to the total plant expenditure, and such that the equipment when in operation will have a positive earning capacity. It must pay dividends the same as any other part of the plant equipment.

Coal handling equipment is not confined in use to central stations and the larger industrial plants. Labor supply and costs and coal market conditions are such that mechanical handling of coal is proving economical for the smaller plants. There is no reason to believe that these conditions will change materially in the future. The prospective purchaser for the small plant need not entertain any fear as to the loss of earning capacity by this equipment.

In this issue, J. E. Borland reviews the general conditions as met in coal handling problems and describes the coal handling facilities of the Colfax and Springdale stations. These two plants represent the utmost in coal handling equipment development. Their operating conditions are such that they require absolute reliability and low cost of operation and maintenance.

Boiler Efficiencies in Small Power Plants

We read a great deal in current engineering literature regarding boiler efficiencies in the order of 83, 84, and even as high as 88 per cent. Such reports are indeed gratifying to the engineer's mind, and when he reads them he is, no doubt, filled with a sense of satisfaction to know that the country's fuel resources are being so efficiently utilized. We pride ourselves on being connected with a profession that is instrumental in conserving the natural fuel resources on a large scale.

Now, it is perfectly true that great advances have been made in recent years in methods of burning fuel, and we have no intention of diminishing the importance of these advances, but we must not lose sight of the fact that such advanced methods are in use in only a limited number of plants and that there are a vast number of small plants throughout the country where only the most rudimentary methods are employed. Our central stations and some of the high grade industrial power plants where the 82 and 83 per cent efficiencies are being obtained, are by no means the largest consumers of fuel, and we must not let their dazzling performance blind us to the inefficient practices used in the majority of the smaller plants.

Investigation will show that somewhere between 50 and 70 per cent of the smaller power plants in this

country are being operated in an alarmingly wasteful manner. In most of these instances the average boiler efficiency will not exceed 55 per cent, and in many cases are far below even that figure.

While it is not possible in these plants, which range anywhere between 50 and 1000 boiler horsepower, to obtain central station efficiencies, it should be possible to approach 60 or 65 per cent without any great additional outlay for new equipment. In many cases the installed equipment is entirely adequate, and the poor economy is merely the result of lack of proper operating knowledge.

By the intelligent use of a few simple instruments, such as a draft gage and a CO_2 indicator, not a recording meter, but something that will enable the operator to determine from time to time what is going on inside the furnace, such plants can be placed on an efficient operating basis.

Here then is a fruitful field for the engineer who wishes to reduce his fuel bill and who is conscientiously concerned in conserving the nation's fuel resources. An average increase of say ten per cent (and this is entirely possible) in the efficiency of these smaller plants would save far more coal than will the one-half of one per cent the central stations and the high grade industrial plants are striving so hard for.

Off Duty

During the few odd millions of years we humans have been acquainted with Dame Nature, we have found her to be a capricious individual and have become accustomed to many of her tricks. Not content with harboring a multitude of secrets, she has hidden them in the most unexpected places, and it has taken years of effort on the part of our scientists to uncover a few of them.

Her hiding places are many and varied, but coal it seems, was one of her favorites and she hid an almost endless variety of things in it. We are all familiar with the story of coal tar—how, from the dirty black residue which results from the carbonization of coal, the chemist has extracted a thousand and one wonderful products—how the gorgeously colored dyes used in our textile mills, the dainty flower-scented perfumes Milady uses, and the ultra-high explosives which make gun-cotton look sick by comparison, are all made from one and the same thing—coal-tar. That's an old story, although the wonder of it never dies, for who would expect to find in a dirty lump of coal all the glorious hues of the rainbow? Nobody—except a chemist, and it was a chemist who found them there.

But, as we said before, he found other things as well, and phenol, commonly known as carbolic acid, was one of them. Now, phenol in itself is a mighty useful substance because of its disinfecting properties and one would think that after having hidden this substance in coal, Nature would have been satisfied, but she was not. She endowed this substance with a peculiar affinity for certain other substances, such as, for instance, formaldehyde. When formaldehyde and phenol are brought in contact they seize upon one another with remarkable avidity and form a combine of unusual tenacity, that is, a resin.

Now, this much was known as far back as 1872 but nothing was done about it. Chemists, as a rule, fought shy of resins because resins were usually the result of an unsuccessful experiment, and, once formed, nothing could be done with them. They could not be dissolved, or crystallized or distilled and therefore could not be purified, analyzed or identified. A resin was the end of the chemical rainbow so to speak, and there the matter usually ended.

However, as Edwin E. Slosson puts it, chemists, like governments, have learned wisdom in recent years, and they have found these resins or "unsuccessful mergers" very useful in their way. Shortly after 1909, L. H. Baekeland, the inventor of Velox photographic paper, undertook a systematic study of the now called "phenol condensation products" and found that when equal weights of phenol and formaldehyde were mixed and warmed in the presence of a suitable catalytic agent, the solution separated into two layers, the upper aqueous, and the lower, a resinous precipitate. This resin, if heated under pressure, changed into another and new kind of resin that was hard, inelastic, unplastic, infusible and insoluble. The chemical name of this produce—don't get excited now—is, "polymerized oxybenzyl methylene glycol anhydride," but nobody calls it that, not even the chemists. It is called "Bakelite" after its inventor.

If you are a radio fan, further explanation is unnecessary, for to a radio fan, bakelite is what water is to a fish or what beans are to a Bostonian. He lives in an atmosphere of bakelite and nothing so pleases him as the acrid odor of carbolic acid, as he drills holes through the bakelite panel for his radio set. In this form, Bakelite is familiar to most of us. But it is made into a great many other things.

Beads and pipestems of bakelite have the clear brilliancy of amber and much greater strength. Toilet articles, clocks, airplane propellers, fountain pens, lamp shades, noiseless gears for automobiles and other machinery, electric switch parts, billiard balls, insulators, jewelry, waterproof lacquers for brass work, fancy pencil holders, impregnating varnishes and a host of other things are all made of bakelite or one of the other phenol condensation products, Redmonol and Condensite. It has aptly been named, "the material of a thousand uses."

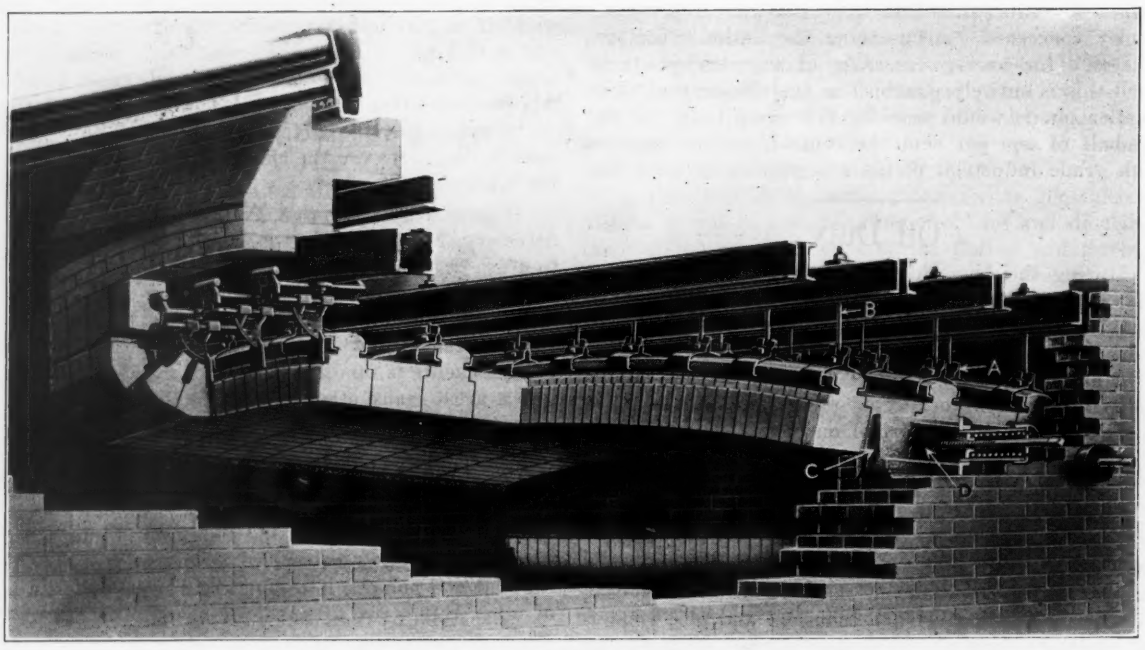
Its ready workability lends it to hundreds of uses. For instance, porous wood, cardboard, cloth, wood pulp, sawdust, asbestos, etc., may be impregnated with the resin, producing a hard, tough material which not only has excellent electrical insulating properties, but is also capable of withstanding high temperatures. It can be sawed, cut, drilled, machined, polished, moulded, pressed with wonderful facility. It can be made black, or clear transparent amber; it can be clouded with wonderfully delicate, nebulous streakings, or can be colored with all the variegated hues of a sunset sky; indeed, its application is limitless.

Some day, perhaps, someone with a fanciful turn of mind will write an "Arabian Nights of Modern Times." If such a book is written, bakelite will have a foremost place in it. In the meantime, however, it stands a fitting monument to its inventor and to the realm of chemistry to which it owes its existence.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

Novel Arrangement of Suspended Arch

SEVERAL novel features of design are incorporated in a suspended sprung arch which is now being built by the American Arch Co., of New York City. The arch is entirely independent of the inner lining of the furnace, due to the method of suspension and lateral motion caused by expansion and contraction is taken care of by skew blocks held in position by springs. In addition to the suspension of the blocks by the special fittings, the arch is built up on a radius similar to the usual sprung construction. Through this arrangement all of the blocks are under slight pressure, and should a tile crack or spall, the pieces are not so apt to drop out.



LATERAL MOVEMENT DUE TO EXPANSION IS TAKEN CARE OF BY THE SKEW BLOCKS (MARKED C) WHICH ARE HELD BY SPRINGS

As will be noted from the accompanying illustration, short pieces of angle runner engage the heads of the hung tile, and these angles are gripped by steel clips which are attached by eyebolts to the channels or angles spanning the furnace. Between these hung tile a special filler tile forms an interlocked construction.

Side thrust is small since it is only sufficient to maintain the brick to radial lines. The force exerted for wide arches does not exceed 3 to 3½ lb. per sq. in. on the area of the skews. The pressure exerted through the floating skews is automatic. There is enough initial compression on the springs to maintain tight joints, regardless of shrinkage, and in the event of expansion the bricks are relieved of injurious compression which would tend to disintegrate them.

With vertical-pass boilers, the high velocity gases have an easy release on the up-turn around the rear of the arch. The radius is generous, which also tends to reduce the amount of erosion. This part of the arch is similar to the body, both filler and hung brick being used. The hung brick are supported by clips attached to the cross members.

In the accompanying illustration, a part of the ignition arch is also shown. The construction of this is similar to the main arch.

When the arch is laid to a radius, as is the standard practice, each tile is slightly tapered. When required to meet special conditions, as under low-set boilers, or to accommodate vertical powdered coal or refuse burners, the arch may be installed flat.

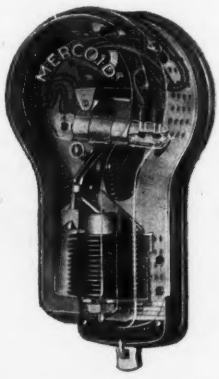
With large boilers, single set, a series of compression springs is used on both sides of the furnace. With boilers in battery, a solid skew is built on the center wall, and expansion and contraction are taken care of with one series of springs in the outer side wall.

Mercury Contact Principle Is Applied to Thermostat

MERCURY as applied to the closing of an electrical circuit has been used in the development of pressure operated switches by the Federal Gauge Co., of Chicago, but this organization only recently utilized the same idea for thermostats. As in the case of the pressure switch, the contact making device is a sealed glass tube containing inert gas and mercury and having no exposed conducting surface. This type of contact eliminates open-arcing and prevents corrosion or oxidation.

Movement of the glass tube is obtained through the use of a sealed metal bellows containing expansive liquids or gases. It is also furnished with flexible stem or bellows when used for brine tank control.

As this thermotat will safely carry 10 amp. at 110 v. or 5 amp. at 220 v., the use of remote control on motors of 1 hp. or less is eliminated.



WHEN TEMPERATURE CHANGES, TUBE TILTS AND MERCURY CLOSES THE ELECTRICAL CIRCUIT

The trade name of the thermostat is the "Mercoid," and it is applicable to electrically operated and controlled oil burning equipment, refrigeration and general industrial work.

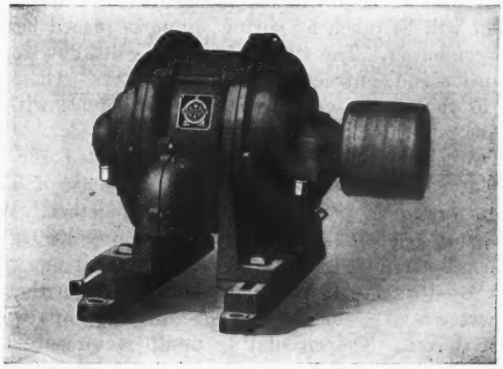
Reliance Adds Line of Induction Motors

RIVETED frame construction, cast end-rings on rotor and removable conduit connections are among the features of a new line of induction motors which has been developed by the Reliance Electric & Engineering Co., of Cleveland, Ohio. This organization formerly specialized entirely on direct current machines, and was responsible for the development of the armature shifting design to give adjustable speeds as great as 1 to 10 without the use of external controlling equipment. The new line of alternating motors has been added after several years' experimental work and test applications in various plants.

Frames of motors in sizes up to 25 hp., 1800 r.p.m. are of the riveted construction. The stator punchings are assembled with end flanges, under 10-T. pressure. Large rivets are inserted, the ends electrically heated and upset.

Slots in the stator punchings are semi-enclosed, although the slot opening is ⅛ in. Coils are wound of cotton covered enameled wire, and the completed stator is given a dipping and baking treatment which is repeated three times.

Punchings for the rotor core are assembled on the skew plan and the rotor bars of hard drawn copper are



RELIANCE INDUCTION MOTOR WITH SLIDE RAILS AND PULLEY

fitted into the slots. End-rings of copper are cast onto the extensions of the bars and are then machined down to size.

One point of interest in the design is the type of conduit connection used. This outlet box is split and may be removed in order to give free working space at the time the connections are made.

Two 30,000-Kw. Units to Be Added to Colfax Station

PLANS for the extension of the Colfax station by the Duquesne Light Co., of Pittsburgh, call for the addition of two 30,000-kw. units to the present station rating. These units, together with their auxiliaries, have been purchased and work on the station extension is making progress.

These new units are the Westinghouse combination impulse and reaction, single cylinder turbines, rated at 35,000 kv.a. and include 1562 kv.a. house generator coupled to the main generator. The units are designed to operate with 265 lb. steam pressure, 175 deg. superheat and 29 in. vacuum.

Each turbine is arranged with four openings at various stages, so that steam can be extracted for the purpose of heating the boiler feed water. At the 30,000-kw. load, the pressure at these bleeding points is approximately 126 lb., 59 lb., 15 lb. and 3.75 lb. absolute.

Auxiliary house generators which are driven by the main units supply the energy for driving all of the auxiliaries for the particular unit, all of the auxiliaries being driven by motors. Excitation for both the main generators and the auxiliary house generators will be obtained from a three element motor driven exciter set. This special exciter set consists of one 350-kw. d.c. generator to supply excitation current for one or both of the main generators, and a 50-kw. d.c. generator to supply excitation current for one or both of the auxiliary house generators. Both the 350-kw. and the 50-kw. generators are driven by one induction motor.

Turbine generator units will be served by two 55,000-sq. ft. radial flow, two-pass, surface condensers. The water boxes will be divided to permit cleaning one-half of the condenser while the other half is in operation. Each condenser will be equipped with one inch outside diameter number 16 BWG Admiralty metal tubes. The condensers will be bolted to the turbine exhausts by means of cast iron exhaust connections. Part of the weight will be taken by spring supports placed beneath each condenser. The spring supports will allow for the expansion and contraction of the condensers. The center line of the condenser will be at right angles with the turbine generator center line.

Two circulating pumps will be provided for each condenser. Each pump will have a capacity of 35,000 g.p.m. when both pumps are operating together. When one pump operates alone, it will deliver 46,000 g.p.m. against the reduced head. This will permit one pump being used during light load periods, or when the cooling water is at a low temperature. The pumps will be motor driven. The circulating pump motors are to be of the wound rotor type, equipped with non-reversing mechanism, which will prevent the pumps from being reversed when the motor is thrown from one bus to another.

Dwight P. Robinson & Co. of New York City are the consulting and erecting engineers.

Iron and Steel Electrical Engineers to Meet at Buffalo

DURING the week of Sept. 24, the Association of Iron and Steel Electrical Engineers will hold its annual convention at Buffalo. Besides the technical sessions there will be an Iron and Steel Exposition at the Broadway Auditorium. One of the features of this exposition will be a complete electrified foundry which will demonstrate modern foundry practice under actual working conditions.

Among the technical papers to be presented are the following:

"Electrically Operated Centrifugal Pumps," B. A. Cornwell, electrical engineer Carnegie Steel Co., Youngstown, O.

"Slip Regulators," D. M. Petty, electrical engineer Bethlehem Steel Co., Bethlehem, Pa.

"Electrical Developments," W. Kennedy, power engineer Worth Steel Co., Claymont, Del.

"Standardization," F. W. Cramer, engineer of tests Bethlehem Steel Co., Johnstown, Pa.

"Safety," Walter Greenwood, safety engineer Carnegie Steel Co., Youngstown, O.

"High-Pressure Steam Boilers," Dr. D. S. Jacobus, consulting engineer Babcock & Wilcox Co., New York.

"Automatic Engine Stops," Walter Greenwood, safety engineer Carnegie Steel Co., Youngstown, O.

"Electric Furnaces," E. T. Moore, electrical engineer Halcomb Steel Co., Syracuse, N. Y.

"The Tempering of Coal," T. A. Marsh, chief engineer Green Engineering Co., Chicago.

"Surface Combustion," W. N. Hepburn, vice-president Surface Combustion Co., New York.

"Electrification of the Iron and Steel Foundry," L. W. Egan, consulting engineer, Cleveland.

"Skip Hoists," A. C. Cummins, electrical engineer Carnegie Steel Co., Duquesne, Pa.

"Boiler Troubles from the Operating Man's Standpoint," Carl Smith, fuel engineer Inland Steel Co., Indiana Harbor, Ind.

"Special Control for Ore Bridges with Special Reference to Wind Velocities," Paul Canney, electrical engineer Minnesota Steel Co., Duluth.

"Systematizing the Work of the Electrical Engineering Division," P. T. Vanderwaart, electrical engineer New Jersey Zinc Co., Palmerton, Pa.

"Electric Transportation in Steel Mills," F. O. Schnure, electrical superintendent Bethlehem Steel Co., Sparrows Point, Md.

"Economical Use of Fuel in the Steel Plant," H. C. Seibert, fuel engineer Bethlehem Steel Co., Bethlehem, Pa.

Quigley Fuel System Becomes Associated with Fuller Engineering Co.

AN AGREEMENT has been reached between the Fuller Engineering Co. and Quigley Fuel Systems, Inc., whereby the Fuller organization will act as sole licensees in the United States and Canada for all new business of the Quigley method of utilizing pulverized fuel in furnaces. The idea behind the combination is that of rendering a more complete engineering service, since by this arrangement designs can be presented from a wider selection of pulverized fuel equipment.

In the Quigley system, the air transportation method differs essentially from the Fuller screw conveyor and high pressure blast systems in that the fuel is transported in bulk from the pulverizing plant through pipe by compressed air. The coal travels in slugs from a blowing tank unit.

Stoker Sales Over 500,000 Hp. for First Half of 1923

ONE OF THE indications of the extensive developments in the power plant field is afforded by the statistics on stoker sales issued by the Bureau of the Census through the Department of Commerce. According to the reports of 15 of the principal manufacturers, 1019 stokers, totaling 517,000 hp., were sold during the period from Jan. 1 to Aug. 1 of this year. Of these stokers, 102, totaling 14,000 hp., are for installation under fire-tube boilers, while 917, totaling 503,000 hp., are to be used under water-tube boilers.

HENRY L. DOHERTY, president of the Cities Service Co., recently announced the formation of the Public Service Co. of Colorado, a new subsidiary which is to include the Denver Gas and Electric Light Co. of Denver, the Western Light and Power Co. of Boulder and the new power plant development at Valmont, Colo.

Plans for the new company provide for financing the completion of a steam turbine electric generating plant at Valmont and for tying together the Denver and Boulder properties with high tension transmission lines.

Recorder Draws Curve of Water Level

IN ADDITION to visual and audible signals the water level alarm shown in the accompanying illustration furnishes a permanent record of the water level, through the use of a curve drawing instrument. The recorder pen is operated by lever train actuated by a cork and copper float.

Should the water level be either too high or too low, a gong alarm sounds, and continues to ring until the water level is restored. In addition to the gong alarm,

FLOAT ACTUATES RECORDER PEN AND LIGHTS FLASH AND GONG RINGS WHEN WATER LEVEL REACHES HIGH OR LOW POINTS

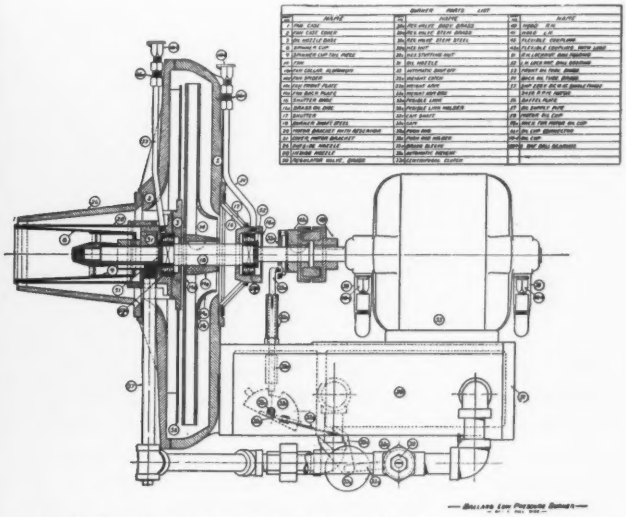
the float operates two light signals. If the water gets too high, a red light shows at the top; if too low, a red light shows at the bottom of the recording chart. Foaming of water will also raise the float and operate the signals.

This water recorder is built by the Hackman Mfg. Co., of Milwaukee.

An Electrically Operated Oil Burner

IN AN EFFORT to produce an efficient oil burner which will operate without objectionable noise, for use in theaters, office buildings, etc., the Ballard Oil Burning Equipment Co., of Boston, has developed the burner shown in the accompanying drawing. This is a mechanical, low pressure oil burner which atomizes the oil at the periphery of a spinner cup which revolves at a high speed and spreads the oil into a thin film. The burner is driven by a ½-hp. Westinghouse motor, through a flexible coupling, the shaft being mounted on ball bearings. The shaft carries a fan, as shown, the air from which serves to break up the film of oil as it is spun off the periphery of the spinner cup. The air from the fan presses between two nozzles, the inner nozzle preventing the air from coming in contact with the spinner cup except at the periphery where it deflects the oil forward with a clean continuous cutting force. This nozzle also allows the cup to become hotter, reducing the viscosity of the oil and eliminating the accumulation of carbon on the cup.

Air control is entirely automatic. When the quantity of oil being burned is reduced, the amount of air admitted to the air box is reduced proportionally to prevent the waste of heating the excess of air passing through the fire box. This automatic air control gives



SECTIONAL VIEW OF THE BALLARD LOW PRESSURE BURNER

a great range of flexibility to the fire. The burner will operate with oil pressure as low as 5 lb. and can be started with 14 to 16 deg. fuel oil at ordinary temperatures without the use of gas, electric or other auxiliary heaters.

Safety devices are provided so that should the motor shaft stop or the oil, allowed through carelessness to accumulate beneath the burner, catch fire, the oil supply to the burner is shut off automatically and the oil from the pumps is bypassed back to the storage tank.

Two New Plants for Kentucky

CONSTRUCTION of a high power transmission line, connecting the new $2,000,000 power plant of the Kentucky Utilities Co., on the Cumberland River near Pineville, and the proposed $4,000,000 plant on Dix River, has been authorized by the utilities company, according to announcement by R. M. Watt, district manager.

The Dix River plant will be erected by the Kentucky Hydro-Electric Co., a subsidiary of the Kentucky Utilities Co., and the connecting high tension transmission line may be used to supply power and light to Barbourville, Corbin, London, Mt. Vernon and Lancaster, through which it will pass, much of the neighboring country to the main line and supply the power for constructing the big Dix River plant, with which the local plant, the Varilla plant and the Pocket, Va., plants will be connected.

St. Louis River in Minnesota to Be Fully Developed

IMPROVEMENTS involving the investment of $7,000,000 and including the building of two more power units and the erection of a 110,000-v. power line from Duluth, through Cloquet, to all cities on the range of Minnesota will be undertaken by the Phoenix Utilities Co., with headquarters at Duluth, in order fully to harness the St. Louis River in northeastern Minnesota. The hydroelectric holdings on this river were recently bought by the American Light and Power Co., an Eastern corporation.

Between Cloquet and Lake Superior, a distance of about 20 mi., the St. Louis River has a total drop of 578 ft. This is developed in the following locations:

	Ft. head
Knife Falls	19
NW. Paper Co.	40
Stevens Dam	16
Scanlon-Carlton	53
Thompson	374
Fond du Lac	68
Total	570

In the purchase made by the American Light and Power Co. were included the properties of the following: The General Light and Power Co., the Great Northern Power Co. and the Duluth-Edison Co., all of Duluth, Minn.; the St. Louis River Power and Improvement Corporation, and the General Light and Power Co. of Cloquet, Minn. Besides the power units, the purchasing company gets control of several large storage dams, and all riparian rights on St. Louis River and its tributaries. The unit of the Northwest Paper Co. is not included in the sale.

As the St. Louis River has been used by the Weyerhaeuser Lumber interests for over 30 yr. to drive their logs from the timber section of Minnesota to their three sawmills at Cloquet, this was taken care of by a stipulation in the sale whereby the American Light and Power Co. will build several miles of railroad and will pay the cost of having the logs taken from the river above the first storage dam, loaded on cars and railed to the mills at Cloquet.

When all the units are in operation, which will be late in 1924, a total of 134,000 hp, will be developed. Of this, Duluth, Superior and the Iron Range cities will use approximately 70,000. In the city of Cloquet, the Northern Lumber Co. is now driving its planing mill with electric power. The other two sawmills are making arrangements to use this energy. The Wood Conversion Co., the Berst Manufacturing Co., the Northwest Paper Mill and the Rathborne, Hair & Ridgway box factory all tap into this line for power.

Plants at the Scanlon-Carlton site and at Fond du Lac are yet to be constructed. Engineers are now at work on a new project about 3 mi. up the river from Cloquet. This will furnish another power dam, with a 53-ft. head, and will make the St. Louis River's power fully developed.

When the 110,000-v. power line is completed, it will make a loop covering the whole northeastern part of Minnesota, including the ports of Duluth and Superior, Cloquet—where the Weyerhaeuser sawmills for the north-central section of United States are located and the iron mining cities of Coleraine, Nashwauk, Hibbing, Chisholm, Ely, Tower, Eveleth and Biwabil. It will also branch out to Babbit, where the iron-mining industries have a plant for partially refining the ore that does not contain enough iron to pay for shipping in its mined states.

The Phoenix Utilities Co. now has 1500 men on construction, and work will be pushed to completion.

Oklahoma Company to Enlarge Plant

CONSTRUCTION work on an addition to the plant of the Oklahoma Power Co. on the Arkansas River, a few miles south of Tulsa, will be started early this fall, according to an announcement made recently by Fred W. Insull, president of the Public Service Co. of Oklahoma. The expense incurred in building and equipping the addition will be more than $600,000.

In the new unit there will be installed a 10,000-kw. turbine which has already been purchased and which will be placed in operation upon delivery there.

Two transmission lines, one aerial and the other under the river, now serve the city, thus giving the insurance of interrupted service. A third line serves West Tulsa and insures interrupted service. A third line serves West Tulsa and the refineries there, while a fourth goes to Sapulpa, Muskogee and other cities. The Oklahoma Power Co. now furnishes electricity to an area of 500 sq. mi. in this territory.

News Notes

PLANS FOR the 1923 Chemical Exposition, which will open at the Grand Central palace, New York, on Sept. 17 and extend for one week, opening daily at noon and closing at 10 p. m., are completed. Beside the 400-odd exhibits which are expected by the time the exposition opens, two other features have been planned for this year. They are a moving picture program of industrial films to be shown each afternoon and evening in a special auditorium for the purpose, and an intensive course in the practical business side of chemical enpineering for students in various universities all over the country Detroit Edison Co. Changing Railway Supply Lines from 25 to 60 Cycles

UEHLING INSTRUMENT CO., Paterson, N. J., combustion engineers and manufacturers of steam power plant economy apparatus, including CO_2 recorders, have appointed three new Southern representatives, namely, Connor-Hudson Co., Southwestern Life Bldg., Dallas, Texas; Gibbens and Gordon, Inc., 532 Canal St., New Orleans, La., and the Cornell Mathews Co., 10 Oak St., Orlando, Fla.

DETROIT EDISON CO. will install seven 1000-kw. 60-cycle railway converters with single-phase 23-000-v. transformers and automatic switching equipment, in seven new sub-stations along the line of the Port Huron Division of the Detroit United Railways. The Detroit Edison Co. is changing the 25-cycle transmission line supplying this railway to 60-cycle, and instead of recon-

structing the old sub-stations, it was decided to build entirely new ones for complete automatic operation. The sub-station equipment will not include high tension oil circuit breakers but three single-phase transformers will be connected to the transmission line through high tension expulsion type fuses. The fusing of power transformers for supplying industrial service is the general practice of the company. The new stations will be built of sheet steel on steel framing. The Westinghouse Electric & Mfg. Co. is to supply the equipment.

OLAF E. OLESON has resigned as president of the Edward Valve & Mfg. Co., East Chicago, Ind., and W. H. Crawford has been elected to succeed him.

HENRY D. JACKSON, formerly of Monks & Johnson, consulting engineers, has joined Templeton Bros., Inc., manufacturers of steam traps, Boston, Mass., as treasurer.

DR. THOMAS ADDISON, often called the father of the electrical industry in the West, has retired at his own request as Pacific Coast manager of the General Electric Co., and will be succeeded by J. A. Cranston, formerly Northwestern manager. Mr. Addison has been with the company for 33 yr., and has held his present position since 1892.

WIGHTMAN-HICKS, INC., is the name under which the businesses of Charles Austin Hirschberg, Inc., and Lucius I. Wightman have been consolidated. Officers of the new firm are Lucius I. Wightman, President; H. L. Hicks, Vice-President and Treasurer, and E. M. Hoberg, Secretary. The offices will be at 50 Union Square, New York. Telephone: Stuyvesant 2029-30.

ENGINEERS OF the Cities Service Co. have selected for the Melco, O., plant of the Ohio Public Service Co. two Westinghouse Brown-Lipe variable speed power transmissions for stoker service. It is interesting to note that this new power transmission has a reverse speed which enables the stoker operator to back up the fuel feeding rams and remove any material should be in the coal.

GRAHAM BRIGHT, formerly general engineer in charge of the coal and metal mining activities of the Westinghouse Electric & Manufacturing Co., has joined the firm of Howard N. Eavenson & Associates, mining engineers of Pittsburgh, Pa. Mr. Bright will give special attention to power house systems, power plant appraisals, transportation and transmission systems for coal and metal mines, and general industrial power applications.

A PRELIMINARY permit covering the development of a power station at the proposed United States lock at the Falls of the Ohio River near Louisville was issued recently by the Federal Power Commission to the Louisville Hydro-Electric Co. Application of the city of Louisville for a similar permit was rejected by the commission. Plans filed by the company indicate the purpose to develop 75,000 secondary horsepower.

HUHN MANUFACTURING Co., now producing metal packing for all service conditions, announces that A. R. Neff has been appointed its West Coast manager, with offices at Room 3, Ferry Dock, Seattle, Wash., and 2 West 7th St., Long Beach, Calif. C. E. Hermansader and Joseph Mangano have been appointed West Coast service men. The company's interests in San Francisco will be handled through Ford and Geirrine, with offices at 326 Exchange Block.

LOUISVILLE GAS & ELECTRIC Co., to keep pace with the growing city, is planning an extension to the boiler-room of the plant on the river front as far as Washington St. at an estimated cost of $520,000. The extension calls for an increased horsepower of 20,000, making a total of 120,000 hp., when the improvement is completed. The company now is completing extensive improvements at the Riverside plant. A turbine generator of 20,000 kw. has just been installed and is running. According to engineers, the plant is one of the most economical in the country.

A RUNAWAY COAL TRAIN on the New Haven Railroad crashed into the plant of the Edison Electric Illuminating Co. at East Bridgewater, Mass., recently, wrecking the machine shop and a big crane and doing damage of $25,000. Power was shut off from East Bridgewater for 24 hr. as a result of the accident.

ENGINEERS of the Goodyear Cotton Mills of Goodyear, Conn., are investigating the dam of the company with a view to rebuilding part of the dam and enlarging the power plant of the company. The present dam has been in use for half a century.

TREMONT NAIL Co., of Brockton, Mass., is reecting a new powerhouse over the dam built a year ago which will increase the available power for the company.

CONSTRUCTION of a new dam at Day's Mills, Sanford, Me., has started. The work is being done by the Day's Mill Dairy Co. to furnish power for that company. The dam will be 120 ft. in length and 30 ft. high.

MIANUS DIESEL ENGINE Co. has been incorporated at Stamford, Conn., with an authorized capital of $1,500,000. Burgess Osterhout of 147 Ocean Ave., Brooklyn, N. Y., is at the head of the new company and is assisted by New York and Connecticut men in the enterprise.

ANNOUNCEMENT has been made of the change in name to indicate the consolidation of the Schaeffer & Budenberg Mfg. Co. and the American Steam Gauge & Valve Mfg. Co. The new name will be the American Schaeffer & Budenberg Corporation.

AS A RESULT of suit recently brought in the Federal Court in New York City by The Permutit Co. against the Paige & Jones Chemical Co., for infringement of the former company's patent covering Zeolite water softening apparatus, Judge Learned Hand granted an injunction against the latter company restraining it from further manufacturing or selling the infringing apparatus. This patent had previously been sustained by the District Court at Buffalo and the Circuit Court of Appeals, New York.

ONE OF THE largest copper wire mills in the world, with an ultimate capacity of 70,000,000 lb. of copper wire a year, is expected to be completed late this year when a group of buildings now under construction at the Western Electric Co.'s plant at Hawthorne is finished.

L. W. SEELIGSBERG has established an office for Industrial Advertising Service at 50 Church St., New York. Telephone: Cortlandt 5490.

SOUTHERN SIERRAS POWER CO. will commence work immediately on a $500,000 power plant on Mill Creek, in the San Bernardino mountains. The plant is expected to develop 3000 hp. and be an important link in the power system extending from Bishop, Cal., to the Imperial Valley.

IT IS ANNOUNCED that the Northern Pacific Railway shops at Brainard, Minnesota, are to have a new steam power plant added for which the initial budget of the railway provides approximately $650,000. It is believed that the entire construction cost will come close to $1,000,000.

Books and Catalogs

LECTURES ON ENGINEERING PRACTICE, edited by John B. Whitehead, 6 by 9 in., paper, 90 pages, 50 illustrations; published by the Johns Hopkins Press, Baltimore, 1923.

At the school of engineering of the Johns Hopkins University, Baltimore, it is the policy to give a series of lectures on engineering practice which will give the under-graduates some idea of the practical phases of present-day engineering problems. The series of lectures given during the school year of 1922 and 1923 covered the following subjects: "The Relation of Highway Research to Modern Road Construction," by A. T. Goldbeck, chief, Division of Tests and Research of the U. S. Bureau of Public Roads; "Possibilities for Steam Railroad Electrification," by Norman Wilson Storer, general engineer of the Westinghouse Electric & Mfg. Co., and "Power Development—Past and Future," by Geo. A. Orrok, consulting engineer for the New York Edison Co.

Mr. Orrok's lecture takes up the study of power development from the earliest times and traces the influence of the various changes which have been made in equipment, on the economies which have been obtained in power plant practice. He shows how we are gradually approaching the theoretical limits of securing the most work out of the actual heat units contained in a pound of coal. The early Newcomen engines of 1800, without Watt's improvements, figured on the kilowatt-hour basis, would have required 416,000 B.t.u. Large central stations of the most modern type are producing a kilowatt-hour with as low as 17,000 B.t.u., and Mr. Orrok points out that this will quite likely be reduced to 15,000 B.t.u., with an ultimate goal of 10,000 B.t.u. to work for.

RILEY UNDERFEED SUPER STOKERS are covered in publication No. A1, issued by the Sanford Riley Stoker Co., of Worcester, Mass. In this bulletin attention is called to the fact that in a comparatively short period of time, this stoker has been developed from its original depth of 8 ft. 8 in. up to that of the present super stoker, which varies from 11 ft. 8 in. to 19 ft. 1 in. in depth and is capable of burning up 3000 lb. of coal per retort per hour. This single-ended stoker takes the place of the double-ended type which was the practice for large boilers previous to the development of the super stoker. It is claimed that the cost of the boiler unit is considerably reduced because of the reduction in the number of coal bunkers and coal feeding equipment. Cross sections of the stoker form a part of the bulletin and illustrations are presented showing the arrangement in the furnace.

SHEPHARD ELECTRIC CRANE & HOIST CO., of Montour Falls, N. Y., is distributing a 68-page booklet which shows the various applications which have been made of the Lift About electric hoist.

PENBERTHY INJECTOR CO., of Detroit, Mich., has issued data sheets entitled, "Directions for Locating Injector Troubles," in which considerable information is given as to the care and operation of injectors.

HANNA PNEUMATIC RIVETERS are illustrated and described in catalog No. 5, now being distributed by the Hanna Engineering Works, Chicago, Ill. Sizes range from 4 in. to 21 ft. reach, and capacities from 10 to 150 T.

LARGE POLYPHASE INDUCTION MOTORS are discussed in bulletin No. 1087D, issued by the Allis-Chalmers Mfg. Co., of Milwaukee. These motors are of the type suitable for operating hoisting equipment, large ventilating fans, steel plate mills and other such equipment. The range in rating varies from 100 hp. up to 5000 hp.

IN A PAMPHLET issued by the Boiler-Kote Co., Chicago, Ill., the properties of its refractory for filling and surfacing furnace walls are fully stated. Experience of users of Maphite is quoted from their letters, showing its heat-resisting powers, its tenacity of bonding to brickwork and its durability under severe furnace conditions.

BULLETIN No. 177 of the Uehling Instrument Co., Paterson, N. J., illustrates, in diagrammatic form, the simple principle of operation of Uehling CO_2 recording and indicating equipment. The diagram shows the essential parts of the equipment arranged as a train and includes the features employed in obtaining a clean, dry and desulphurized sample of gas, which is of such paramount importance in flue gas analysis.

"NINETEEN STORIES OF LIME" is the title of a booklet which is being distributed by the Central Division of the National Lime Association, of Chicago. In this booklet, the association presents in pictorial form the many uses which have been made of lime in connection with concrete. Letters are also presented from various engineers and contractors giving their viewpoint on the value of lime in making concrete waterproof. According to the booklet, it is now common practice to add a certain amount of dehydrated lime to concrete used for fuel oil tanks, water tanks and stacks.

LACLEDE-CHRISTY CLAY PRODUCTS CO., of St. Louis, has recently issued two bulletins, one entitled, "Burning Pocahontas Coal on a Conveyor Feed Stoker" and the other entitled, "The Stowe Stoker." "Burning Pocahontas Coal" is taken up by presenting the results obtained at the plant of the Gloucester Electric Co. where the Stowe Stoker is successfully handling this type of fuel. The bulletin on the Stowe Stoker explains the principles of combustion which were taken into consideration in the design of this stoker. It goes on to show how the stoker meets these requirements, and then discusses the mechanical details of the stoker design.